COPY No.

RESTRICTED

THE SCHOOL
OF
CONTROL AND REPORTING

FIGHTER PLOTTERS

LECTURE NOTES

RESTRICTED

AMENDMENT RECORD SHEET FOR FIGHTER PLOTTERS LECTURE NOTES

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FIGHTER PLOTTERS LECTURE NOTES

CONTENTS

SECTION 1 : AIR DEFENCE

PRECIS 1 : AN AIR DEFENCE SYSTEM

INTRODUCTION

1.1. The function of any air defence system must be to protect the defended area from air attack (including airborne landings) by:-

(a) Destroying enemy aircraft

(b) Harassing the enemy aircraft, thereby reducing the accuracy of their attack

(c) Minimizing the effects of successful attacks.

1.2. To enable this to be done, the system must possess:-

(a) Suitable weapons

(b) Means of using these weapons

(c) A component organization by which the system can be alerted

1.3. Contemporary weapons of air defence are:-

(a) "Day" and "All-weather" fighter aircraft

(b) "Heavy" and "Light" anti-aircraft artillery

(c) Guided missiles

(d) Defensive radio-countermeasures

(e) Means of target concealment (smoke screens, camouflage etc.,)

(f) Decoy targets

(g) Measures taken for civil defence (air-raid warning services, fire fighting and bomb disposal units, medical services etc.).

Weapons (a) (b) and (c) are active; (e) (f) and (g) passive; (d) part active, part passive.

1.4. The means for using these weapons include:-

(a) Airfields and launching sites

(b) Air-navigation and landing aids

(c) Supply services

(d) Communications

(e) Skilled personnel

(f) A tactical control organization to ensure that the weapons are deployed and employed in order to gain maximum advantage over the enemy

(g) A fighter control system for guiding fighters towards attacking enemy aircraft, essential because of:-

(i) The great altitudes at which attacking aircraft can fly

(ii) The high speed at which attacking aircraft can operate

(iii) The need to intercept in conditions of cloud, bad visibility, and darkness

1.5. The component organization to which is assigned the task of alerting the air defences is known as a "reporting system". Fully developed reporting systems also greatly assist those exercising control functions, by continuing to track enemy raids after first detection and by reporting the movements of friendly aircraft.

THE CONTROL AND REPORTING SYSTEM

1.6. The activities of tactical control, fighter control, and reporting are interdependent and are best discharged by a single integrated organization. This is known as a Control and Reporting (C. & R.) system.

Reporting Organization

1.7. A fully developed reporting system seeks to achieve the aims mentioned in para. 5 by:-

(a) Operating a chain of early warning radar stations which:-

(i) Are positioned to afford maximum vertical and horizontal cover over the approaches to the defended area

(ii) Maintain a continuous search for long range incoming responses which may well be the first indication of enemy air attack

(b) Maintaining a network of reporting units - both radar and ground observer teams, the former including those mentioned in para. 7(a) above - charged with the task of reporting all activity (both friendly and hostile) significant to the air defence organization.

(c) Producing a continuous and current air-picture as a means both of alerting and informing the control and civil defence organizations.

1.8. General Situations Maps (G.S.Ms.) This picture is displayed to the users on general situations maps. A G.S.M. is a map of the defended area (or any part of it) and its approaches, upon which symbols are moved indicating air activity.

1.9. Symbols. In order that the air activity be adequately represented, the symbols must show as accurately as possible for each unit of air activity (formation or single aircraft):-

(a) Position

(b) Direction of flight

(c) Strength

(d) Height

This process is known as track production. To complete the picture a further process is necessary, that of determining the track's identity (hostile or friendly). This is known as raid recognition.

1.10. A Reporting System under Attack. A reporting system must be able to operate when the enemy:-

(a) Takes offensive action against it, by:-

(i) Electronic interference

(ii) Physical assault

(b) Attempts to overwhelm the defenses by attacking in great numbers (saturation tactics).

Control Organization

1.11. The task of the control organization is:-

(a) To exercise tactical control, which involves:-

(i) Ensuring that weapons are held at suitable states of preparedness

(ii) Meeting every attack however many there may be, with best use of weapons available

(iii) Ensuring the most economical use of weapons when attacked by superior enemy forces

(iv) Co-ordinating the effort of the air defences of the whole area

(b) To direct fighters ("fighter control") against attacking enemy aircraft.

1.12. Tactical Control. To ensure the most effective tactical control of the defences of any large area, it is expedient:-

(a) To divide the total area into "sectors"

(b) To delegate responsibility for tactical control to the Commander of each sector

(c) To exercise overall control of the sectors (as and when necessary) from a central point in order to:-

(i) Reinforce hard pressed sectors

(ii) Co-ordinate the efforts of all sectors.

1.13. Fighter Control. To fulfil its function (para. 4(g)) of directing fighter aircraft into contact with enemy aircraft, the fighter control system must:-

(a) Possess complete radar cover over the defended area and its approaches

(b) Have an efficient method of communication with airborne fighter aircraft

(c) Continue to operate through radar and radio interference

(d) Not breakdown when the enemy employs "Saturation" tactics.

STATIC AND MOBILE DEFENCE SYSTEMS

Static Defence System

1.14. This type of system (e.g. that of the United Kingdom) is suited to the defence of large areas containing the resources on which a nation depends for the prosecution of a major war.

Mobile Defence System

1.15. This type (e.g. that associated with the Second Allied Tactical Air Force) is best suited for use in areas where the land battles are expected to be fluid.

Note

Trainees will be expected to concentrate their studies upon the static air defence system of the U.K. this being the most highly developed of all air defence organizations.

SECTION II : THE REPORTING SYSTEM OF THE UNITED KINGDOM

PRECIS 2 : THE REPORTING ORGANIZATION IN THE UNITED KINGDOM

INTRODUCTION

2.1. Function. The task of the United Kingdom's Reporting System is to:-

(a) Detect at the earliest possible moment all enemy aircraft (or long range missiles) approaching Great Britain

(b) Provide to the various users a continuous, current, picture of all air activities (hostile and friendly) over Great Britain and its approaches which is significant to the air defence organization.

2.2. Users Served. The air picture produced is displayed on general situation maps (G.S.Ms.) and is used principally by:-

(a) Sector Controllers (representing Sector Commanders) and their staffs to enable them to bring the necessary air defences under their control into action.

(b) Fighter Controllers at G.C.I. (Ground Controlled Interception) stations, to enable them to identify targets allotted to them by their parent Sector Operations Centres (S.O.Cs.).

(c) The Command Controller in the Air Defence Operations Room, to enable him to maintain overall direction and co-ordination of the air defences of the country.

(d) Anti-Aircraft (A.A.) Artillery officers, for early warning and recognition of approaching targets.

(e) Civil Defence Authorities, to control the air raid warning system, through which the passive defences such as fire services, bomb disposal units etc., are alerted.

2.3. Reporting Terminology. The student should be familiar with the special meaning which the following words have acquired in reporting usage:-

(a) "Raid" Any unit of air activity, whether it be a single aircraft or a formation, hostile or friendly is known as a "raid".

(b) "Track" The represented movement on a display table of a raid, is known as a "track".

SOURCES OF INFORMATION

Reporting Sources

2.4. Reports on air activity are received from:-

(a) Radar stations.

(b) Royal Observer Corps posts (via R.O.C. centres - see Precis 4, para. 3).

(c) Other sources - these include pilots' sighting reports.

2.5. Radar Stations. Various types of radar equipments are used, each having a specific role to play in providing maximum horizontal and vertical cover over the U.K. and its seaward approaches (see Precis 11).

2.6. Royal Observer Corps. The R.O.C. reports aircraft movements over-land and coastal waters. Depends on human visual and aural powers. Reports are restricted by visibility and height limitations but the R.O.C. is a valuable source of information concerning aircraft flying below radar cover.

THE PASSAGE OF INFORMATION FROM SOURCE TO USER

2.7. Deployment of Radar Reporting Units (R.R.Us.)

(a) R.R.Us. of different types are used together in order to provide complete vertical coverage over a given horizontal area. Consequently, considerable vertical overlap commonly exists between stations of different types (See Fig. 1).

(b) R.R.Us. of any one type are usually sited sufficiently close together to produce a considerable amount of overlapping cover. This is necessary as a safeguard against damage to, or failure of a station.

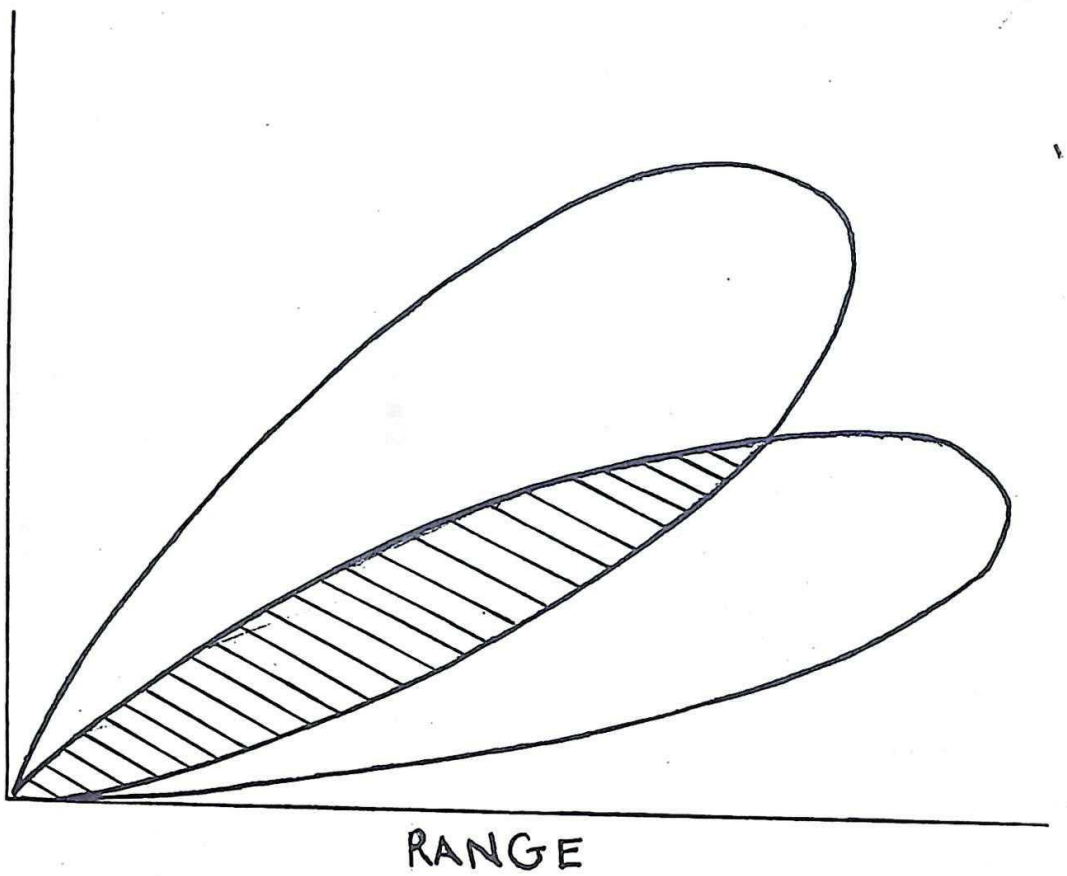


Fig 1

2.8. Resultant Multiplication of Reports

(a) Because of the overlapping cover of R.R.Us., aircraft are frequently under simultaneous observation by more than one station.

(b) The multiple reports so occasioned often differ in their estimates of the true position, strength and height of the same raid.

(c) To transmit all these varying reports direct to the G.S.Ms. would produce a confused and exaggerated picture.

(d) Hence all reports are subjected to a 'filtering' process before being displayed.

2.9. Filtering. As a result of filtering the "raw" information:-

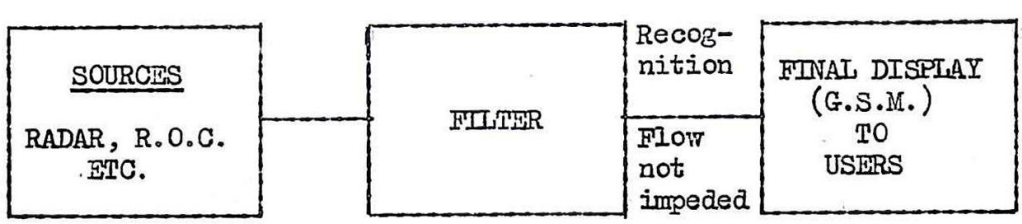
(a) All duplication of reports should be eliminated.

(b) Inaccuracies in individual reports can be reduced by correlation with current reports from other stations and earlier reports from the same station.

(c) A number of disjointed reports concerning a raid can be compounded to form a continuous, coherent, track (a process known as 'track production').

2.10. Raid Recognition. For the final display to be useful to the user a clear distinction must be made between hostile and friendly tracks. This is achieved largely by a process of elimination (e.g. by having pre-knowledge of all movements of friendly aircraft and relating it to the filtered picture). The responsibility for this process, known as raid recognition is delegated to a specialist section within the reporting centre (see Precis 23).

2.11. Necessary Path of Reports. Consequently reports must be subjected to treatment in the following sequence:-



2.12. Centralized Combined Filter Plot (C.C.F.P.). In the United Kingdom, both track production and raid recognition are affected at a number of centres known as Centralized Combined Filter Plots (C.C.F.Ps). The reporting sources (radar, R.O.C. etc.) feed their information to C.C.F.Ps., the C.C.F.Ps. feed their filtered air pictures to the users' G.S.Ms.

2.13. Communications. All communication between reporting sources - filter - and users are carried out over a network of direct landlines. Between reporting sources and C.C.F.Ps. two-waylines are used whereas information passed from the C.C.F.P. to the users is broadcast over unidirectional lines.

SECTION II : THE REPORTING SYSTEM OF THE UNITED KINGDOM

PRECIS 3 : THE CENTRALIZED COMBINED FILTER PLOT

INTRODUCTION

3.1. In each sector there is a centre known as a Centralized Combined Filter Plot (C.C.F.P.) where a current 'air picture' is produced of activity over the sector and its seaward approaches. The limits of a sector's track production area (e.g. that covered by local reporting units) do not, generally, exactly coincide with the sector boundaries, but the divergencies are small.

3.2. Reports are received by plotters seated around display tables (see fig. 1) positioned on the floor of a well lighted room. Balconies around the room afford a clear view of all the tables to those whose task is to:-

(a) Control the composition of the air picture.

(b) Identify the tracks produced.

(c) Tell out the information to the users.

PRODUCING THE AIR PICTURE

3.3. The essentials required to produce a current air picture within a C.C.F.P. are:-

(a) Display Tables. Usually four or five tables of suitable size are used. The breakdown of the map of the Sector area enables filterers and plotters to reach at least to the centre of each table. The combined tables show:-

(i) A complete map of the Sector and its seaward approaches.

(ii) Overlap areas (approximately 30 miles wide) into adjacent sectors.

(iii) A geographical reference (GEOREF - Precis 16) graticule, by which plotting and telling is effected.

(b) Filter Supervisors. One or two supervisors work at each table, dependent on the amount of air activity. They produce the tracks from the 'raw' information displayed by the plotters around their particular table.

(c) Plotters. A number of plotters promptly set out, by means of symbols, information received from their respective reporting sources.

(d) Display symbols. These are of two distinct kinds handled respectively by:-

(i) Plotters - symbols of distinctive colour or shape denoting the individual station and type of radar.

(ii) Filter Supervisors - to display the filtered air picture.

(e) A Recognition Section. Charged with the task of determining the identity of all tracks produced by the filterers.

(f) Tellers. Who tell out the filtered air picture to the G.S.Ms. of the users.

TRACK DESIGNATION

3.4. A track designation consists of a track serial number preceded by a recognition prefix letter.

Track Serial Numbers

3.5. To avoid confusion, each track produced is allotted a serial number (10-999), by which it is known throughout its existance. Serial numbers are painted on strips of metal known as "raid plaques". The remainder of the plaque is used to display ancillary information (Fig. 2).

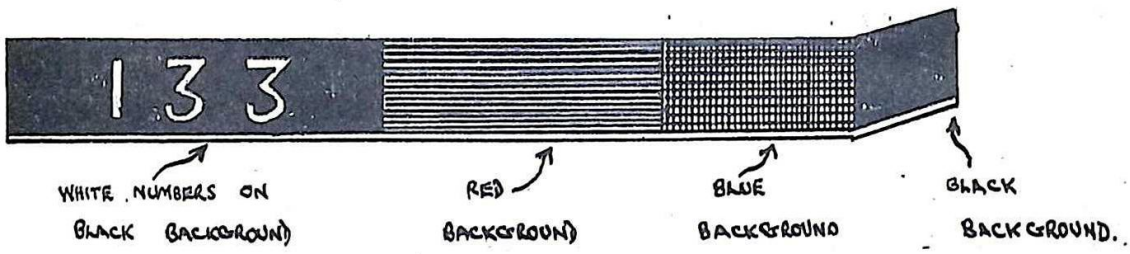


Fig. 2

3.6. Allocation of Serial Numbers. Numbers are allocated to:-

(a) C.C.F.Ps. Each C.C.F.P. has an exclusive block of 3 figure numbers (the allocation is listed in the appropriate F.C.C. & R. Proc. Inst.,). This block is subdivided between the number of tables used, and a number is allotted consecutively to each new track originated on his table, by the filter supervisor concerned.

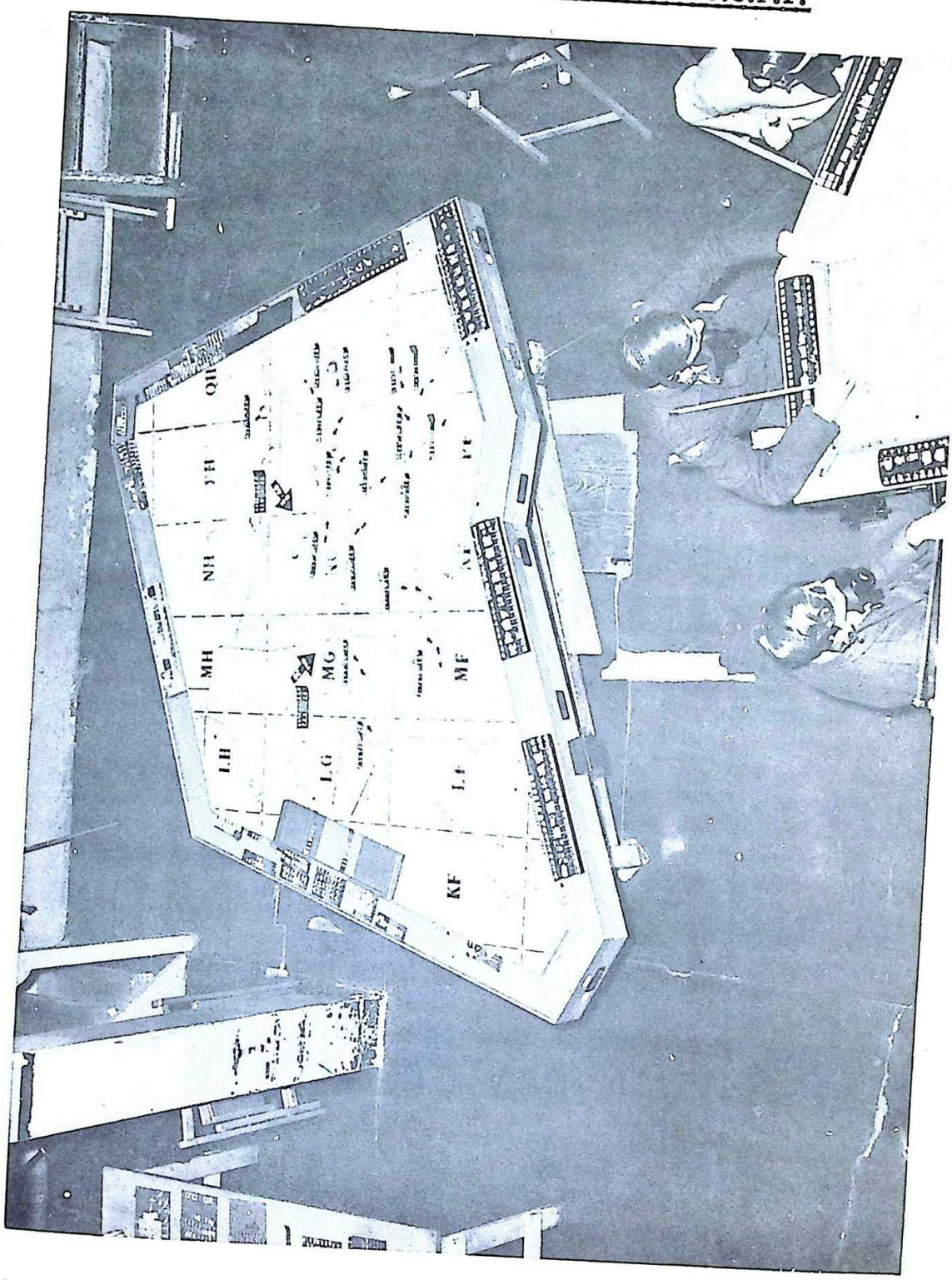
(b) R.O.C. Centres. Each R.O.C. centre uses a block of numbers (10-99) which are allotted consecutively to each track originated by R.O.C. posts within a group area. R.O.C. centres are identified by the addition of a suffix letter to the serial number (e.g. Winchester - '24 W').

NOTE For continuity of tracks passing from Sector to Sector, each C.C.F.P. holds blocks of serial numbers exclusive to other C.C.F.Ps., and serial numbers with suffix letters indicating R.O.C. Centres, beyond its track production boundaries.

Track Identity

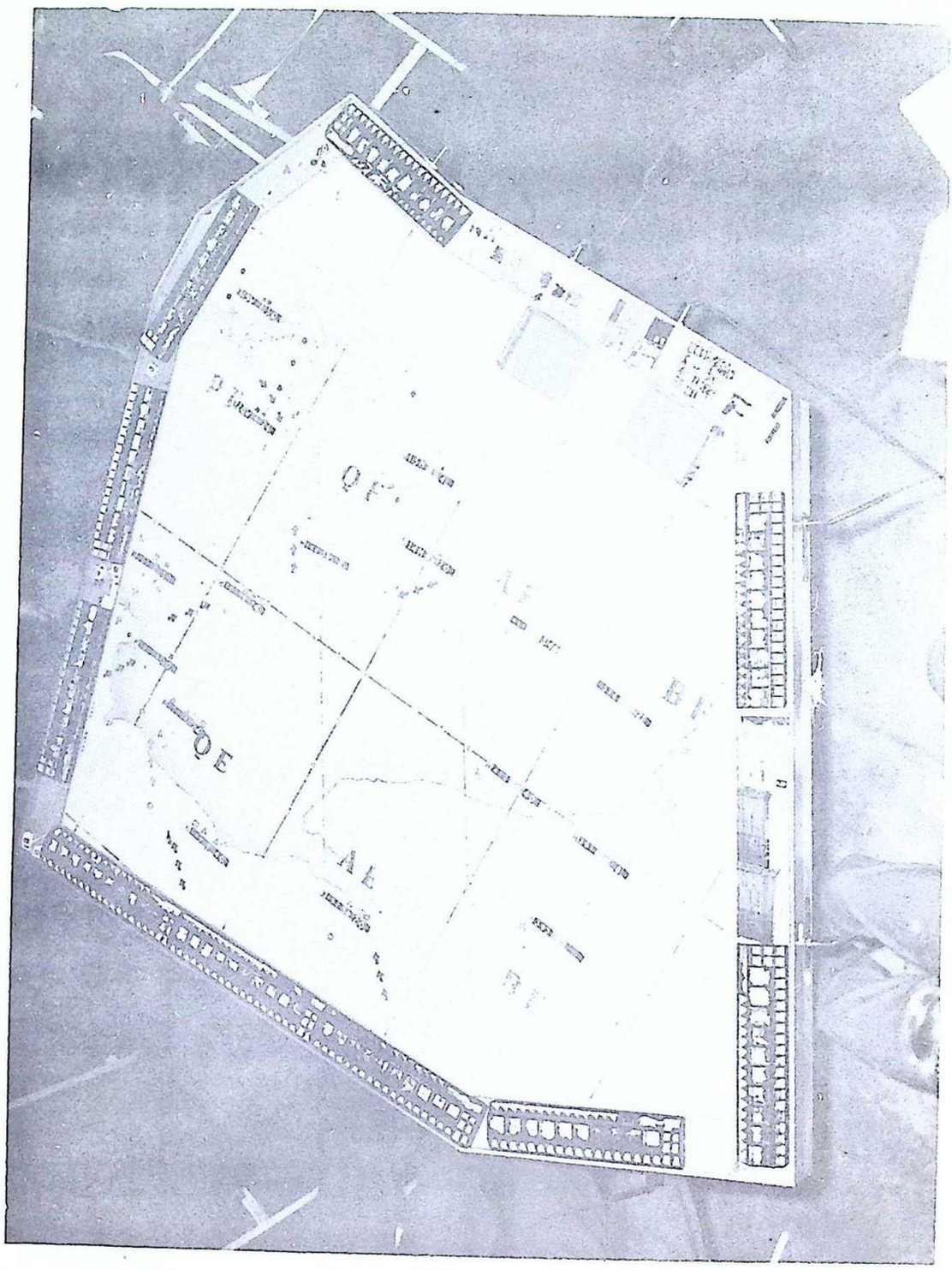
3.7. Prefix Letters. A letter is used to indicate the decision of the raid recognition officer concerning the tracks' hostile or friendly identity. The letters used are:-

Fig. 1 : A View of Plotting Tables in a C.C.F.P.



Precis No. 3, Para. 2

Fig. 3 : C.C.F.P. Display Table Showing Overlap in Adjacent Sector's Area Between Continuous Line and Dotted Line



Precis No. 3, Para. 9(b)(i)

H - hostile

X - unidentified

F - friendly fighter

A - allied (other friendly aircraft)

M - mixup (of friendly fighters with H or X raids)

NOTE A track - during the short time prior to receiving the R.R.Os. decision, having no identification prefix, is known as 'serial' (e.g. "serial 159").

Track Continuity

3.8. There is a possibility that inaccuracies in reports of plan positions received from R.R.Us. on aircraft flying on, or near to, inter-table boundaries, may cause plots to:-

(a) Fall on two adjacent tables and be filtered as separate tracks.

(b) Be ignored by filter supervisors at both tables, each assuming the other is handling the track.

(a) or (b) above could occur either between

(i) Adjacent tables within a C.C.F.P. or,

(ii) Tables at adjacent C.C.F.Ps. (where the inter-table boundary is also the inter-sector boundary).

3.9. The dangers in para. 8 are obviated:-

(a) Internally within a C.C.F.P. by co-operation between the filter supervisors concerned when each:-

(i) Filters the track to his table boundary.

(ii) Filters the first position on the table to which the track passes.

(b) Between adjacent C.C.F.Ps. by an inter-C.C.F.P. plotter/teller handover process where:-

(i) Filter tables of any one C.C.F.P. depict not only the sectors' territory, but also a boundary fringe (overlap), some 20-30 miles deep, being part of adjacent sectors' territories (see Fig. 3).

(ii) Each C.C.F.P. is allowed to filter (and recognize) only within its sector boundaries, overlap information being displayed "for information only".

(iii) An 'overlap' plotter displays overlap information, which consists of both raw and filtered information, passed to him by an 'overlap' teller at an adjacent sector.

Scheme of Overlap Communications between Filter Tables in Adjacent C.C.F.Ps.

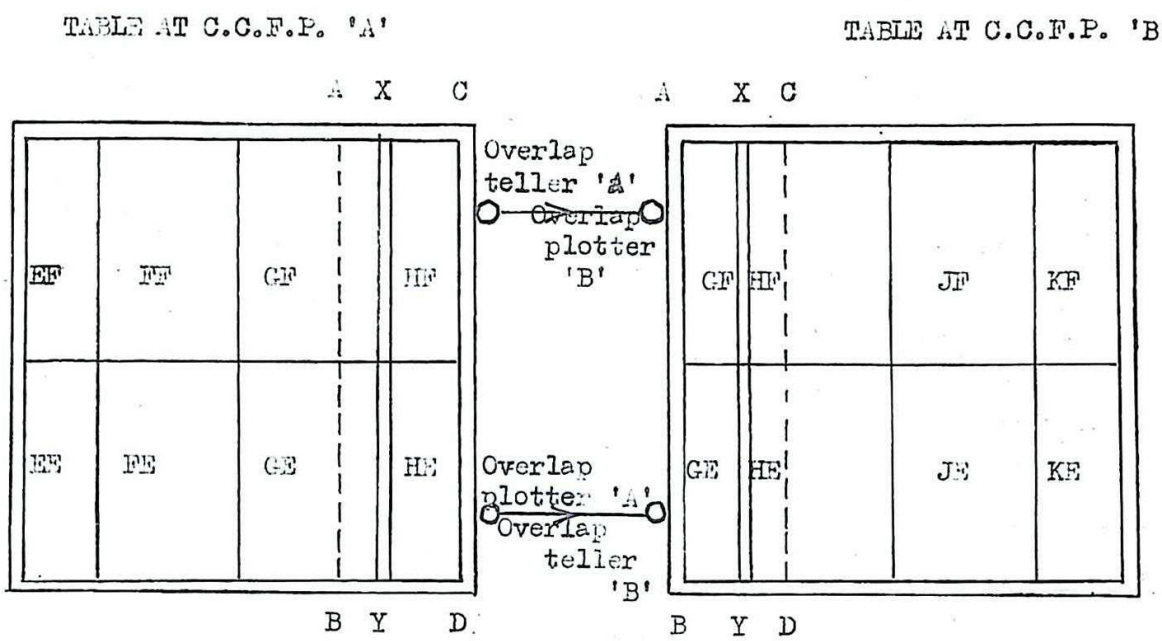


Fig. 4.

Key
XY - Sector boundary
ABYX - C.C.F.P. is B's overlap into Sector A
XYDC - C.C.F.P. is A's overlap into Sector B
Overlap teller 'A' tells all activity within ABYX to overlap plotter 'B'.
Overlap teller 'B' tells all activity within XYDC to overlap plotter 'A'.

Thus all activity in area ABDC appears on both tables the filter supervisor in Sector 'A' being responsible for ABYX, the filter supervisor in Sector 'B' for XYDC.

3.10. By this procedure:-

(a) Each filter supervisor knows which reports are, and which are not, receiving attention, and by whom.

(b) Each filter supervisor can utilize all reports on his tracks, although, because of positional inaccuracies, some plots fall outside his area of responsibility.

(c) Track continuity is maintained.

PERSONNEL AND DUTIES

3.11. C.C.F.P. personnel and their duties are specified in the appropriate F.C.C. & R. Proc. Inst. All students must make themselves fully acquainted with the duties of key personnel within the C.C.F.P. as this will enable them to envisage the complete working of the track production organization.

EQUIPMENT - PROCEDURES AND TECHNIQUES

3.12. For details of C.C.F.P. equipment, and the procedures and techniques adopted for track production, see Precis 18.

COMMUNICATIONS

3.13. Landlines. All information from reporting sources is passed over land-line speech circuits which pass via the 'change-over panel', (C.O.P.) see para. 14, situated within the C.C.F.P. whence they are routed to jacks positioned around the filter tables. Filtered information is 'broadcast' out over a land-line network to the users.

3.14. Change-over Panel. All operational lines to and from a C.C.F.P. pass via this panel which is the responsibility of the floor supervisor. The purpose of the C.O.P. is to enable:-

(a) All lines to be monitored and tested without undue interruption of the flow of information.

(b) Re-routing of lines internally around the filter tables, if and when the occasion demands.

(c) The filter controller to broadcast instructions to all R.R.Us. by connecting the many landlines to a single position on his keyboard.

3.15. Keyboards. Key personnel within the C.C.F.P. are provided with multiline keyboards with:-

(a) Direct 'private line' contact with those to whom immediate and frequent access is imperative.

(b) Lines to an Operations P.B.X. (telephone switch-board) for calls which are important but less frequent.

(c) Lines to the stations' P.B.X. for access to the G.P.O. telephone system.

SECTION II : THE REPORTING SYSTEM OF THE UNITED KINGDOM

PRECIS 4 : THE ROYAL OBSERVER CORPS

INTRODUCTION

4.1. The Royal Observer Corps (R.O.C.) is an integral part of the Reporting System in the United Kingdom. It is, in peace-time, almost wholly manned by spare-time volunteers. In war, whole-time personnel would be directed into the Corps to enable the system to maintain 24 hour watches.

4.2. Function. To observe (either visually or aurally) and report on aircraft movements over the United Kingdom and its coastal waters.

ORGANIZATION

4.3. The R.O.C. operates throughout England, Scotland, Wales and Northern Ireland under the Administrative and Operational Control of the Commander in Chief, Fighter Command. Its status is comparable with that of a fighter group and it is commanded by the Commandant R.O.C., an Air Commodore R.A.F., whose deputy is an Observer Captain R.O.C. It is organized as follows:-

(a) R.O.C. Headquarters located at H.Q. Fighter Command, R.O.C. Headquarters joins with H.Q. Fighter Command Operations staff in determining the policy for the integration of the R.O.C. with other parts of the Reporting System.

(b) Areas.

(i) Administrative control of the R.O.C. is delegated to six area headquarters with territory equivalent to the parent R.A.F. Sector

Metropolitan	-	(Metropolitan Sector)
Southern	-	(Southern Sector)
Eastern	-	(Eastern Sector)
Western	-	(Western Sector)
Northern	-	(Northern Sector)
Scottish	-	(Caledonian Sector)

Each area is commanded by a spare time Observer Captain R.O.C. with a whole time Observer Commander R.O.C. as his deputy.

(ii) Operational Control of the R.O.C. Groups within an area is the responsibility of the appropriate Sector Commander.

(c) Groups. Each area is divided into a number of groups. Altogether there are thirty one R.O.C. groups, each commanded by a spare time Observer Commander R.O.C. whose deputy is a full time Observer Lieutenant.

(i) Operational Function. Operations centres, known as "R.O.C. Centres", are maintained at each Group H.Q. where information from associated R.O.C. 'clusters' (see para. 3(d)) is received and correlated prior to onward transmission to R.A.F. C.C.F.Ps.

(ii) Administrative Function. The R.O.C. Centre and Posts within each group are administered by Group H.Q.

(d) Posts. Dependent on the size of the R.O.C. Group between 30 and 68 posts, situated 6-10 miles apart, report to a Group Operations Centre. A spare time Chief Observer (equivalent to a S.N.C.O.) is in charge of each post. A number of adjacent posts (usually 4 but occasionally 3) sharing a common reporting landline, is known as a 'cluster'. Each post is responsible for observing (visually or aurally) movements of aircraft over its area of responsibility, and, in conjunction with the other posts in the cluster, passing the maximum information on such movements to the R.O.C. centre. All reports are given in approved sequencies and include details of strength, aircraft type, height, plan position and any relevant information considered significant to the air picture.

THE OPERATIONS CENTRE

4.4. Layout. The centre consists of a room with gallery round three sides. On the fourth side is a vertical display board (see 4(d)(ii) below). The room contains:-

(a) Main Plotting Table. This table shows a horizontal map (with 'georef' graticules) of the group territory and immediate surrounds on a scale of 1" = 1 mile (Fig. 1).

(b) Vertical 'Long Range' Plotting Board. This board is a map of the group territory and that of adjacent groups on a scale of $\frac{1}{2}$" = 1 mile (Fig. 2).

(c) Gallery. This gallery is fitted with tables and keyboards used by the controller, supervisors and tellers, and affords a clear view of the displays.

4.5. Personnel. The following personnel are employed in R.O.C. centres:-

(a) Duty Controller. This officer is responsible for ensuring the maximum effective employment of the centre and associated posts as a reporting source and liaises with the R.O.C.L.O. at the parent C.C.F.P.

(b) Assistant Duty Controller. Additionally functions as Inter-Group Liaison.

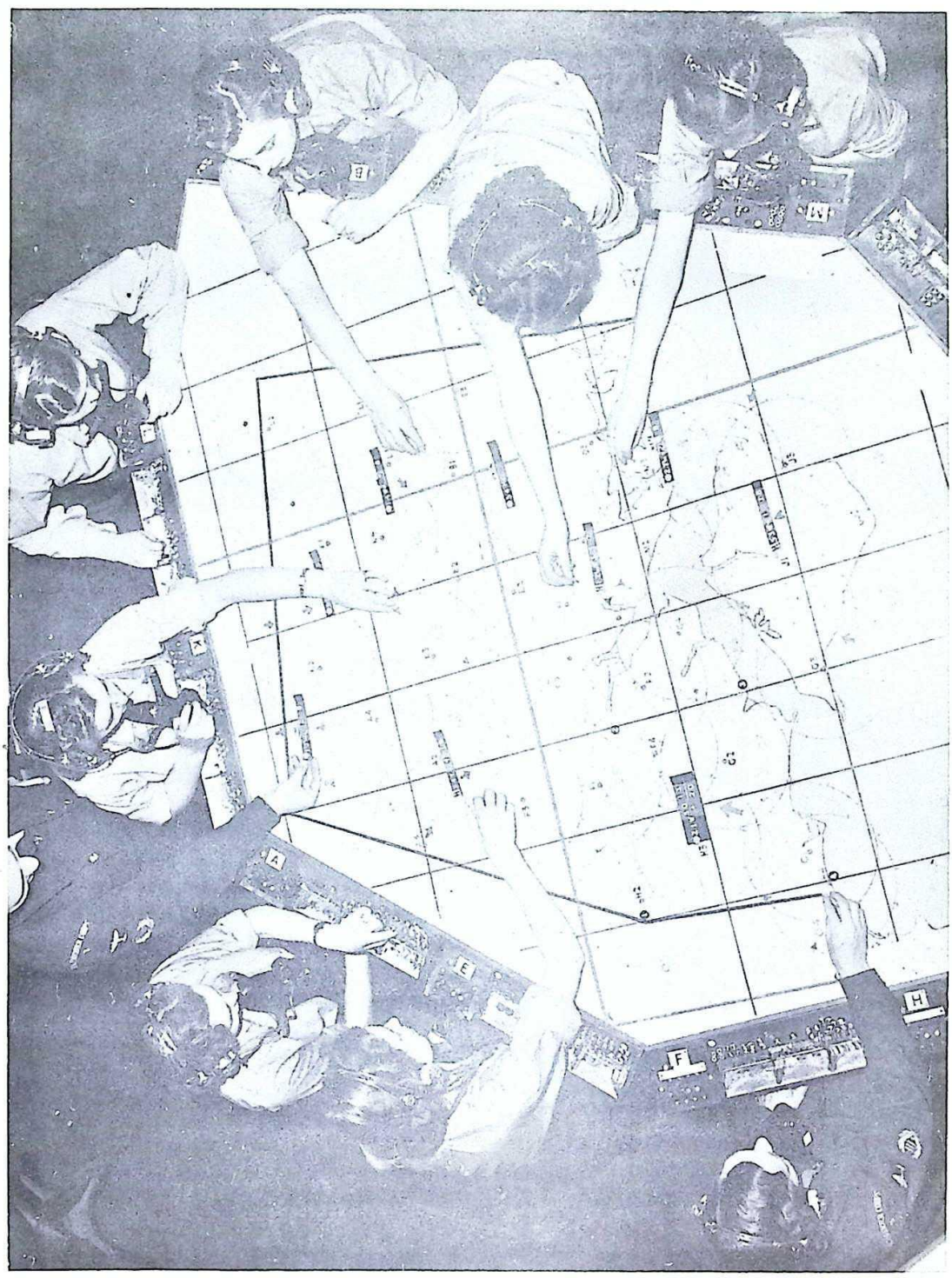
(c) Post Controller. He is responsible to the Duty Controller for the supervision of the reporting activities of the clusters

(d) Plotters.

(i) Main Table Plotters. These plotters, positioned around the table receive reports over land-lines from the clusters and display by means of symbols.

(ii) Long Range Plotters. Tracks approaching the group are displayed by 'long-range' plotters on the vertical board by means of magnetic symbols. This information is received over land-lines from adjacent groups or, in coastal areas, from the C.C.F.P.

Fig. 1 : R.O.C. Operations Centre Main Plotting Table



Precis No. 4, Para. 4(a)

Fig. 2 : R.O.C. Centre Vertical Long Range Plotting Board

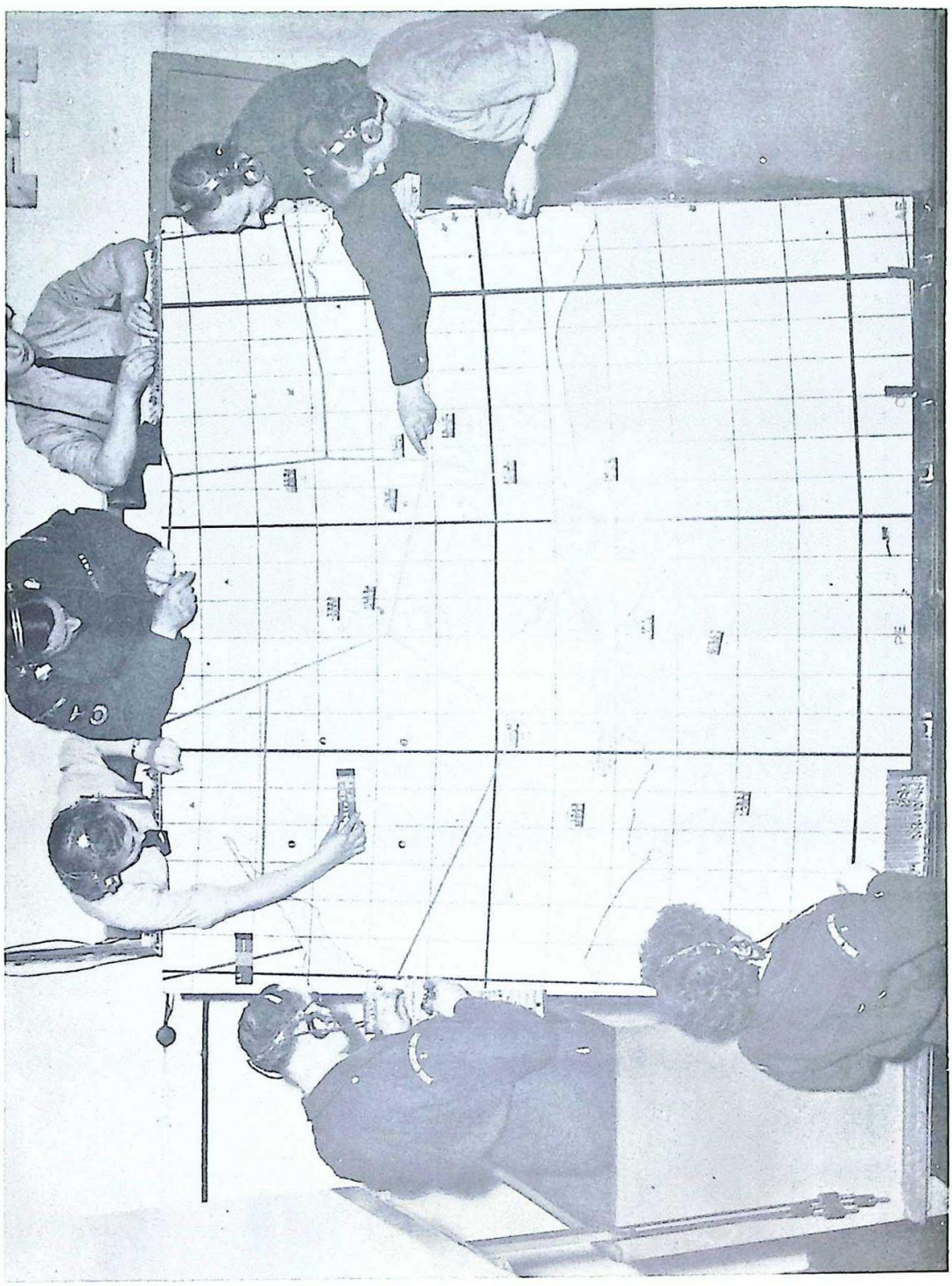
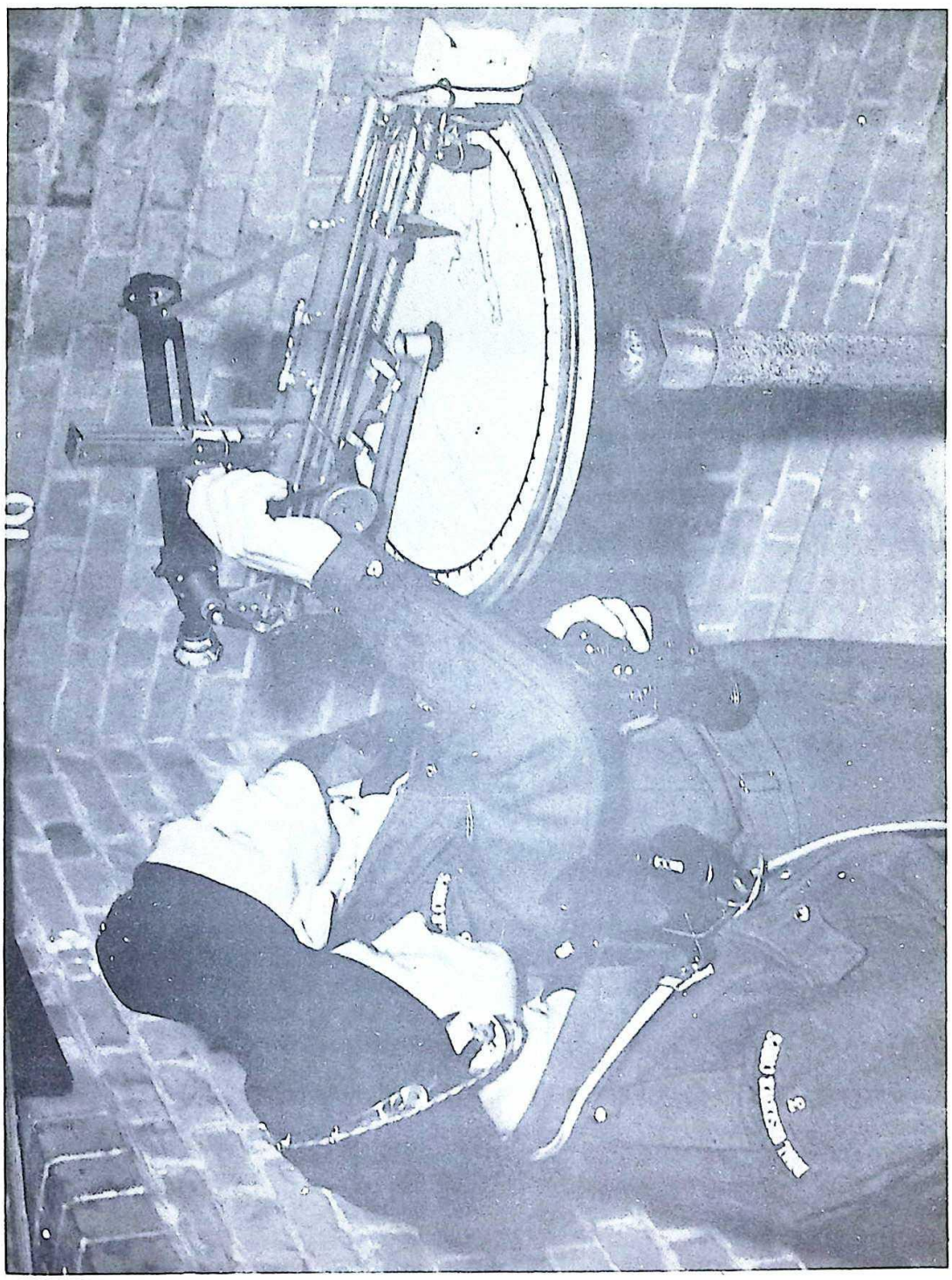


Fig. 3 : R.O.C. Post Instrument



Precis No. 4, Para. 7(a)

(e) Tellers.

(i) C.C.F.P. Tellers. Positioned on the gallery, they report to the C.C.F.P. land table those tracks on the main plotting table recognized as 'Hostile' 'Unidentified' or as 'Friendly Fighters' (or as otherwise instructed by the Filter Controller through his R.O.C.L.O.)

(ii) Inter-group Tellers. They report tracks moving from their group to adjacent groups.

Note:- Floor Supervisors; Table Guides; Recorders and Raid Orderlies are also provided.

THE POST

4.6. The main considerations in the selection of a site for a R.O.C. post are:-

(a) A position which affords the best view of the allotted area of responsibility (e.g. tower, high building, hilltop etc.) having regard to the coverage afforded by associated Posts.

(b) An open topped structure which ensures some degree of protection (sandbagged emplacement, brickwork etc.) against high wind and bad weather.

4.7. Post Equipment. Each R.O.C. post is equipped with the following:-

(a) A Post Instrument (Fig. 3). This is used to calculate plan positions and heights of aircraft.

(b) Binoculars.

(c) Fixed Telephone. Each post shares with other posts in the cluster a telephone line to the R.O.C. Centre. Thus besides reporting activity within its area, a post receives warning of approaching tracks either from the plotter at the centre or by overhearing information passed by other posts within the cluster.

4.8. Personnel. Peacetime strength required to maintain continuous watch at any one post is 16 observers. Each watch consists of 2 observers - one to operate the post instrument, the other to pass the information obtained.

QUALITY OF REPORTS

4.9. In daylight in clear weather tracks of aircraft from ground level up to medium height (say 15,000 feet) are reported with accuracy and speed both in plan position and height. The fact that the R.O.C. recognizes aircraft under these conditions greatly assists the Raid Recognition Officer in his duties. In very clear conditions, as when contrails are forming, accurate tracking at much greater height is achieved. In darkness or when there is low cloud or reduced visibility tracking is dependent on the triangulation of sound bearings from various Posts and the quality of reports is seriously affected.

COMPARISON OF R.O.C. AND RADAR AS OVERLAND REPORTING SOURCES

4.10. The relative effectiveness of the R.O.C. and radar - in overland reporting may be compared as follows:-

(a) Low Cover:-

(i) Radar. Radar is limited by curvature of the earch and screening from hills, woods, buildings etc.

(ii) R.O.C. The R.O.C. suffers from the same limitations but, because its posts are sited much more closely together their effect is substantially reduced.

(b) Medium and High Cover.

(i) Radar. C.H.B. units give good results. Large scale activity may, however, "saturate" the tellers and plotters.

(ii) R.O.C. R.O.C. reporting deteriorates with increasing aircraft height above about 15,000 feet, though below this height the saturation level is generally higher than that of the C.H.B. chain.

(c) Limitations Imposed by Weather Conditions.

(i) Radar. Radar is affected little, or not at all, (dependent on its wavelength) by weather.

(ii) R.O.C. Despite aural reporting, the R.O.C. suffers a reduction in effectiveness in conditions of reduced visibility.

(d) Recognition.

(i) Radar. Recognition is only possible when a radar response can be associated with an IFF response indicating that tracks' friendly identity.

(ii) R.O.C. The fact that the R.O.C. can recognize visual aircraft, assists the Raid Recognition Officer and helps to maintain continuity of tracking in a confused situation. In particular it allows the posts to concentrate their attention on those tracks which are of interest to the defences.

(e) Jamming.

(i) Radar. Vulnerable to radio jamming.

(ii) R.O.C. The R.O.C. cannot be jammed by radio jamming.

(f) Vulnerability to Attack.

(i) Radar. Radar employs exposed aerial systems, difficult to camouflage.

(ii) R.O.C. Any person, anywhere, with a telephone (or radio) can become a reporting source in an emergency. R.O.C. centres are, however, vulnerable to air attack.

EQUIPMENT AND PROCEDURES

4.11. The equipment used and procedures employed by the R.O.C. are described in the R.O.C. manual A.P. 3215.

SECTION III : THE CONTROL SYSTEM OF THE UNITED KINGDOM

PRECIS 5 : THE CONTROL ORGANIZATION

INTRODUCTION

5.1. The A.O.C. in C Fighter Command is responsible for the Air Defence of the United Kingdom and seas within 40 miles of its coast, as the Air Defence Commander, Great Britain.

5.2. Fighter Command is divided into Groups - No. 81 Group - the training group does not concern us here. Nos. 11 and 12 Groups are operational groups and are subdivided into regions, called sectors, each of which contains a number of stations. Each of these levels, except the group level, has responsibilities for the tactical control of operations. In the following paragraphs the control organization and the division of responsibilities within it are described.

ORGANIZATION AND RESPONSIBILITIES

5.3. The control organization together with the reporting organization forms the control and reporting system. Within the control organization operational activities at the higher levels are centred in the:-

(a) Air Defence Operation Centre (A.D.O.C.)

(b) Sector Operations Centres (S.O.Cs.)
There is one S.O.C. per sector.

5.4. Responsibility for Tactical Control. The Air Defence Commanders delegates the responsibilities for tactical control within their areas to Sector Commanders, but retains the responsibility for overall control.

5.5. A.D.O.C. From this centre the Air Defence Controller (the C. in C., or one of his appropriate deputies) exercises:-

(a) Co-ordination of effort. He ensures that adjacent sectors do not duplicate the interception of a raid that appears to threaten both sectors.

(b) Control of Reinforcement. He re-inforces any hard pressed sector with fighter aircraft from other sectors.

5.6. Sector Operations Centre. From this centre the Sector Controller maintains tactical control over the defences of his sector. He:-

(a) Assesses the enemy threat to his sector from a display of the current air activity (G.S.M.).

(b) Initiates action by the defences.

5.7. Subordinate Operational Centres. Orders from the S.O.C. are implemented by:-

(a) Ground Control Interception (G.C.I.) Stations. Fighters are initially despatched to intercept a raid by the order of the Sector Controller. On becoming airborne the fighters are controlled by a selected G.C.I. station. Each G.C.I. station comprises:-

(i) Radars.

(ii) Display hall with G.S.M. showing a duplicate of Sector 'air picture' to enable the Chief Controller to direct the activities of interception controllers working in interception cabins.

(iii) Interception Cabins (commonly 3 or 4) where radar and radio facilities enable the interception controller to direct fighters against the targets specified by the Sector Controller.

(b) Wing Operation Rooms. These centres at the operational fighter stations, are responsible for:-

(i) Implementing orders to despatch fighters (scramble orders) received from the S.O.C.

(ii) Selecting squadrons, flights, sections, pairs or individual aircraft to maintain the preparedness ordered by the Sector Controller.

NOTE: Aircraft at "standby", the highest state of "readiness", may receive an order to scramble direct from the S.O.C. by means of a landline/radio link between the S.O.C. and fighters on the operational readiness platform (O.R.P.). This link is known as "telescramble".

(c) Anti-aircraft Artillery Operations Rooms (A.A.O.Rs.). Orders controlling the fire of heavy A.A. are passed from the S.O.C. to A.A.O.Rs. (one to each "gun defended area") (see NOTE) whence they are relayed to the gun sites.

NOTE: Selected areas (e.g. large industrial districts) are defended by heavy A.A. guns. These are "gun defended areas" and are clearly marked on G.S.Ms. at S.O.Cs. and G.C.I. stations. The Sector Controller, to make the best tactical use of both guns and fighters places certain restrictions on the one or the other when enemy aircraft fly over or near these areas (see Precis 9).

(d) Light A.A. Control Centres. Vulnerable points (e.g. airfields - radar stations etc.) are defended by light anti-aircraft artillery. Orders controlling the use of L.A.A. are originated by the S.O.C. are passed to the L.A.A. control centre and are relayed by R/T to the gun positions.

SECTION III : THE CONTROL SYSTEM OF THE UNITED KINGDOM

PRECIS 6 : THE SECTOR OPERATIONS CENTRE

INTRODUCTION

6.1. The United Kingdom and its seaward approaches are divided into several sectors. The commander of each sector is responsible to the A.O.C. in C Fighter Command for maintaining tactical control of the air defences - fighters and guns - deployed in his sector.

6.2. This task is undertaken at the Sector Operations Centre (S.O.C.) and, because he cannot remain there continuously, he normally delegates these duties to senior officers who act as sector controllers on a watch basis.

6.3. A staff of 'executive officers' each with a particular operational function, implements the orders of the sector controller.

6.4. In order that the sector controller and key personnel may be kept fully informed of the progress of the air battle, various displays are maintained before them in the display hall.

Layout of Operations Room

6.5. The Sector Operations room consists essentially of:-

(a) A display hall in which are arranged:-

(i) A G.S.M.

(ii) A Fighter Table

(iii) 'Rats' Table

(iv) A vertical screen for displaying long range continental early warning information.

(v) A number of cabins from which the users observe these displays.

Displays

6.6. General Situation Map. The G.S.M. is a display map in the form of a table on which the air picture produced by the C.C.F.P. and tracks plotted in adjacent sectors are displayed by means of symbols. The map shows:-

(a) The sector area with boundaries clearly marked.

(b) Considerable areas of adjacent sectors.

(c) Gun defended areas.

(d) Other details considered of importance to the controller (e.g. Sector airfields, G.C.I. stations, large towns etc.).

6.7. Fighter Table. Tracks of airborne fighters under the sectors' control together with tracks of targets (if an interception is being attempted) are displayed on this table by means of symbols. The map shows:-

(a) The sector area in larger scale than the G.S.M. but with only small areas of adjacent sectors.

(b) Gun defended areas.

(c) Sector airfields and G.C.I. stations.

6.8. 'Rats' Table. 'Rat' is the code word used to indicate low-flying hostile or unidentified aircraft. Fighter aircraft employed solely for the task of intercepting such raids are known as 'terriers'. The 'rats' table is used to display 'rat' and 'terrier' information upon a large scale map showing:-

(a) Coastal approaches to the sector area.

(b) Airfields from which 'terrier' aircraft operate.

(c) Gun defended areas.

6.9. Continental Early Warning Screen. Tracks of enemy aircraft which may constitute a threat to the U.K. are passed direct from continental sources to vertical early warning screens at S.O.Cs.

(a) Construction. The screen consists of a vertical sheet of perspex on which is engraved a map of the continental approaches to the U.K. to a range of approximately 300 nautical miles.

(b) Method of Display. Plotters working behind the screen display the air picture by means of wax pencils.

6.10. Tote Displays. To assist the sector controller and his executive staff, the entire wall area opposite the control cabins is taken up by various tote displays comprising:-

(a) Squadron States Tote. This shows the current states of readiness of the sectors fighter squadrons as ordered by the sector controller.

(b) Missions Tote. This shows details of the mission on which fighter aircraft under the sectors' control are engaged.

(c) A.A. States Board. This shows the various gun restriction in force within the gun defended areas of the sector.

(d) Airfield States Board. This shows the current service-ability of sector airfields in terms of:-

(i) Local weather conditions.

(ii) The aerodrome surface (e.g. bomb damage)

(e) R/T Frequency Allocation Board. This display serves to remind the controllers of the availability of R/T frequencies both in the fighter aircraft and at ground control stations within the sector.

NOTE: The totes, tote equipment, and operating procedures are described in Precis 20.

PERSONNEL AND THEIR DUTIES

6.11. Sector Controller. The sector commander's representative, he is responsible for:-

(a) Assessing the enemy threat to his sector by interpretation of the 'air-picture'.

(b) Maintaining the sector fighter squadrons at states of preparedness appropriate to the air situation.

(c) Ordering action against every attack on his sector, using fighter aircraft and A.A. gunfire to gain the maximum success against the enemy.

(d) Implementing the orders of the controller in the Air Defence Operations Centre.

(e) Liaising with controllers of adjacent sectors.

(f) Authorizing movements of friendly aircraft through gun defended areas within his sector.

6.12. Artillery Controller. The artillery controller is responsible for:-

(a) Advising the sector controller on the employment of A.A. defences.

(b) Advising the sector controller of the minute-to-minute capabilities of the A.A. defences within the sector.

(c) Implementing the sector controllers' plan for the integrated fighter/A.A. defence battle. This responsibility he may discharge largely through his H.A.A. and L.A.A. executive.

(d) Liaison with artillery controllers at adjacent sectors. This enables him to inform the sector controller of adjacent sectors' engagement plans and current A.A. control orders. This information is important when fighters pass from one sector to the next.

(e) Maintaining close liaison with A.A.O.Rs. passing information on those developments of the air battle which may affect them.

(f) Ensuring that current meteorological information is passed regularly to A.A.O.Rs.

6.13. Executive Officers. The executive officers work together in a cabin adjacent to the sector controller. They receive orders from the sector controller over a common intercommunication system.

(a) Air Executive. This officer is responsible to the sector controller for:-

(i) Ensuring (through wing operation room) that the sector's fighter squadrons are held at the states of preparedness ordered by the sector controller, and that the squadron states tote is correctly maintained.

(ii) The immediate scrambling of fighters when ordered by the sector controller, giving initial interception (course to steer and height to make) to the pilots (NOTE: The sector controller frequently elects to perform this task himself).

(iii) Diversion of the sectors' fighters to other airfields (i.e. when their parent airfield becomes unserviceable due either to bad weather or enemy attack).

(iv) Briefing (through wing operations room) aircrews before take off, on factors affecting operational sorties (e.g. restrictions over gun defended areas, the general nature of the enemy raids etc.).

(v) Arranging air/sea rescue.

(vi) Having displayed on the tote all relevant and up-to-date information concerning the weather state and the state of sector airfields.

(vii) Liaising with air executives of adjacent sectors.

(b) Control Executive. Acts as the link between the sector controller and the sectors' G.C.I. stations and is responsible to the sector controller for:-

(i) Allocating airborne fighters to G.C.I. stations - through sector fighter marshal (see para. 14), and ordering the handover of fighters from one G.C.I. to another (generally when they pass out of the controlling G.C.I. station's Radar cover).

(ii) Allocating V.H.F. R/T control channels to be used between G.C.I. station and fighters.

(iii) Briefing the G.C.I. stations and sector fighter marshals of the gun restrictions operative throughout the sector.

(iv) Liaison with his chief G.C.I. controllers and the control executive of adjacent sectors.

(v) The safety of aircraft under control.

(vi) Informing the sector controller of the progress of operations.

NOTE: (a) and (b) each have an assistant (usually a junior officer) who keep a log of operations and deals with routine matters.

(c) Heavy A.A. Executive. Acts as the link between the artillery controller and the A.A.O.Rs. and is responsible for:-

(i) Issuing to appropriate A.A.O.Rs. and A.A. totes in the S.O.C. and Sector G.C.I. stations the control orders required to implement the artillery controller's directions on the A.A. part in the air battle.

(ii) Imposing gun control orders to ensure the safety of fighters when they are scrambled, returning to base, or crossing a gun defended area.

(iii) Notifying his artillery controller of the state of A.A. defences and the progress of gun engagements.

(d) Light A.A. Executive. Acts as the link between the artillery controller and light A.A. control centres within the sector, and is responsible for:-

(i) Alerting L.A.A. control centres in the sector.

(ii) Implementing the artillery controller's directions on the control of L.A.A. gunfire by passing the required orders to the L.A.A.C.Cs. affected.

(iii) Passing at least one plot on every hostile or doubtful raid which shows a height of less than 10,000 feet and which passes within 40 miles of any vulnerable point (V.P.) in the sector.

(iv) Keeping the artillery controller informed of the capabilities and states of L.A.A. defences.

Sector Fighter Marshal Organization

6.14. Each Sector employs a 'direction finding' (D/F) organization which 'fixes' the position of airborne fighters whenever they transmit on the Sector 'fixer' frequency. Control of this organization may be exercised either from the S.O.C. or from selected G.C.I. stations.

6.15. Chief Sector Fighter Marshal. If it is desired to exercise control of the D/F organization from the S.O.C. a chief sector fighter marshal is established and is responsible to the sector controller for:-

(a) Overall control of the sector 'fixer' system(s) (some sectors employ more than one).

(b) The handling of all airborne Sector fighters not under G.C.I. control.

(c) Co-ordination of the work of the sector fighter marshals (see para. 16).

6.16. Sector Fighter Marshal. The sector fighter marshal, situated at a suitable G.C.I. station is responsible for the control of airborne fighters in accordance with the orders of the Chief Sector fighter marshal, or in his absence, with the orders of the control executive, especially for:-

(a) Rapid handover of fighters on becoming airborne, to G.C.I. stations.

(b) Control of aircraft awaiting G.C.I. control or returning to base, or in transit to another G.C.I., by means of radar and/or V.H.F. D/F fixes.

(c) Control and operation of one of the sector V.H.F. D/F fixer systems.

(d) Plotting of fighters under his control to the local fighter display.

NOTE: D/F 'fixes' are determined at 'triangulation centres' (one for each fixer system) situated within a single room in the S.O.C. (see Precis 14).

6.17. Rats Controller. There is not to date, a stabilized system for 'rats' interception. One method tried is for the 'rats' controller to direct 'terrier' aircraft against 'rats' raids indicated by tracks on the 'rats' table.

6.18. Sector Intelligence Officer. Is responsible for informing the sector controller on all matters relating to air intelligence, summarizing combat reports etc.

6.19. Meteorological (MET) Officer. Is responsible to the sector controller for correlating all available weather reports and producing a forecast of weather for the sector area (usually 12 hour forecasts). These forecasts are made available to the various users throughout the sector.

6.20. Liaison Officers. Facilities are afforded at S.O.Cs. for liaison officers - naval - civil defence etc.

6.21. N.C.O. i/c Watch and Floor Supervisor. Are responsible to the sector controller for the efficiency and discipline of all crew members. Their duties conform with those of their opposite numbers in the C.C.F.P. These duties are listed in the appropriate F.C. Proc. Inst.

6.22. Plotters. The duties of sector plotters are detailed in appropriate F.C. Proc. Inst. The air pictures on the various tables are displayed by means of symbols, and the information is received on the:-

(a) G.S.M. - from the sector C.C.F.P. and adjacent C.C.F.Ps.

(b) Fighter Table - from:-

(i) Vertical plotting screen at sector G.C.I. stations (see Precis 8)

(ii) Chief Sector and G.C.I. fighter marshals, who report all 'fixes'.

(c) Rats Table - from selected radar stations and R.O.C. centres.

(d) Continental Early Warning Screen - direct from continental reporting sources.

6.23. Raid Orderlies. On the G.S.M., one raid orderly supplies display equipment to 3 or 4 plotters. The fighter and rats tables each have one raid orderly. The display equipment varies at the separate tables but the duties of raid orderly as detailed in the F.C. Proc. Inst. on G.S.M. displays apply to them all.

6.24. Tote Operators.

(a) Tote operators work behind the tote, each of which comprises a large number of horizontal slats.

(b) Information is displayed by plaques which 'hook-on' to the slats.

(c) The passage of information to the tote is either:-

(i) Over landlines - when the tote operators wear head and breast sets,

or (ii) Over a loudspeaker system.

(d) The following are responsible for passing information to the tote operators:-

(i) Wing-operations Rooms at airfields pass changes in aircraft states as they are fulfilled.

(ii) Control Executive Assistant who passes details affecting the Mission tote and R/T allocation board.

(iii) Air Executive Assistant who passes details affecting squadron and airfield states totes.

(iv) H.A.A. Executive who passes gun restriction orders to the A.A. states board.

6.25. Sector Tote Teller and Recorder. Each sector employs a tote teller and a recorder who work as a team in the passing of details of the current display on each Sector's Squadron State and Mission Totes to the tote at the Air Defence Operations Centre. Their duties are detailed in the appropriate F.C. Proc. Inst.

6.26. Sector Fighter Identification Teller. Liaises with the R.R.O. at the Sector C.C.F.P. in the recognition of fighter tracks on C.C.F.P. tables. He is positioned overlooking the sector fighter table and his task is to link tracks of fighters with tracks on the G.S.M. Details of his duties are laid down in the appropriate F.C. Proc. Inst. on Fighter Plotting and Displays.

6.27. The Triangulation Crew. For details of the duties of the personnel who man the "Triangulation Centres" at Sector see Precis 14, paras. 10, 11, 12, 13.

COMMUNICATIONS

6.28. Plotting and Telling is carried out over direct landlines. All key personnel are provided with multiline key boards affording direct contact with those to whom frequent access is imperative.

NOTE: Details of techniques and procedures plotting and tote equipments are contained in Section VI of these precis.

SECTION III : THE CONTROL SYSTEM OF THE UNITED KINGDOM

PRECIS 7 : AIR DEFENCE OPERATIONS CENTRE

INTRODUCTION

7.1. The A.O.C.-in-C. Fighter Command is responsible for the air defence of the United Kingdom, a responsibility which he, or his deputy the duty air defence controller, discharges from one centre, known as the Air Defence Operations Centre (A.D.O.C.).

7.2. From this centre the overall air defence effort is controlled and co-ordinated. The following are typical of the responsibilities of the Air Defence Controller:-

(a) To ensure that the states of readiness maintained by fighters throughout the country is adequate to meet attacks which may develop.

(b) To order the reinforcement of one sector by fighters of another.

(c) To decide which sector shall deal with an enemy raid approaching along or across the boundary between sectors.

(d) To distribute urgent intelligence reports to sectors e.g. to describe the tactics used by the enemy against one sector to other sectors.

7.3. At the A.D.O.C. liaison is established with the other services and with civilian organizations, such as Civil Defence and the B.B.C., whose operations and activities may be affected by the air battle.

THE OPERATIONS ROOM

7.4. The operations room (Fig. 1) accommodates the displays necessary to keep the air defence controller and others informed of all relevant air activity throughout the sectors. A glass-fronted gallery overlooks the display room and is occupied by:-

(a) The air defence controller and his executive staff. They occupy the position directly facing the displays.

(b) Liaison officers - Navy, Army, Allied forces, Civil Defence etc.

7.5. Displays. The displays (G.S.M. and "tote") represent the current air situation throughout all the sectors:-

(a) G.S.M. Details of each sectors' "air picture" are received over broadcast lines direct from the C.C.F.Ps. by plotters on the G.S.M. In the interests of clarity the less important raids may not be displayed. This G.S.M. shows:-

(i) A gridded ('georef') map of the whole defence area and its approaches.

(ii) Gun defended areas.

(b) A "historical plot" on which a record of a few particularly important raids can be retained for the time being.

(c) Tote. Each sector employs a tote teller who passes to the A.D.O.C. tote operator details of current:-

(i) Aircraft states. - the state of readiness of the Sector's fighter aircraft.

(ii) Missions. - the Missions allocated to sector's aircraft.

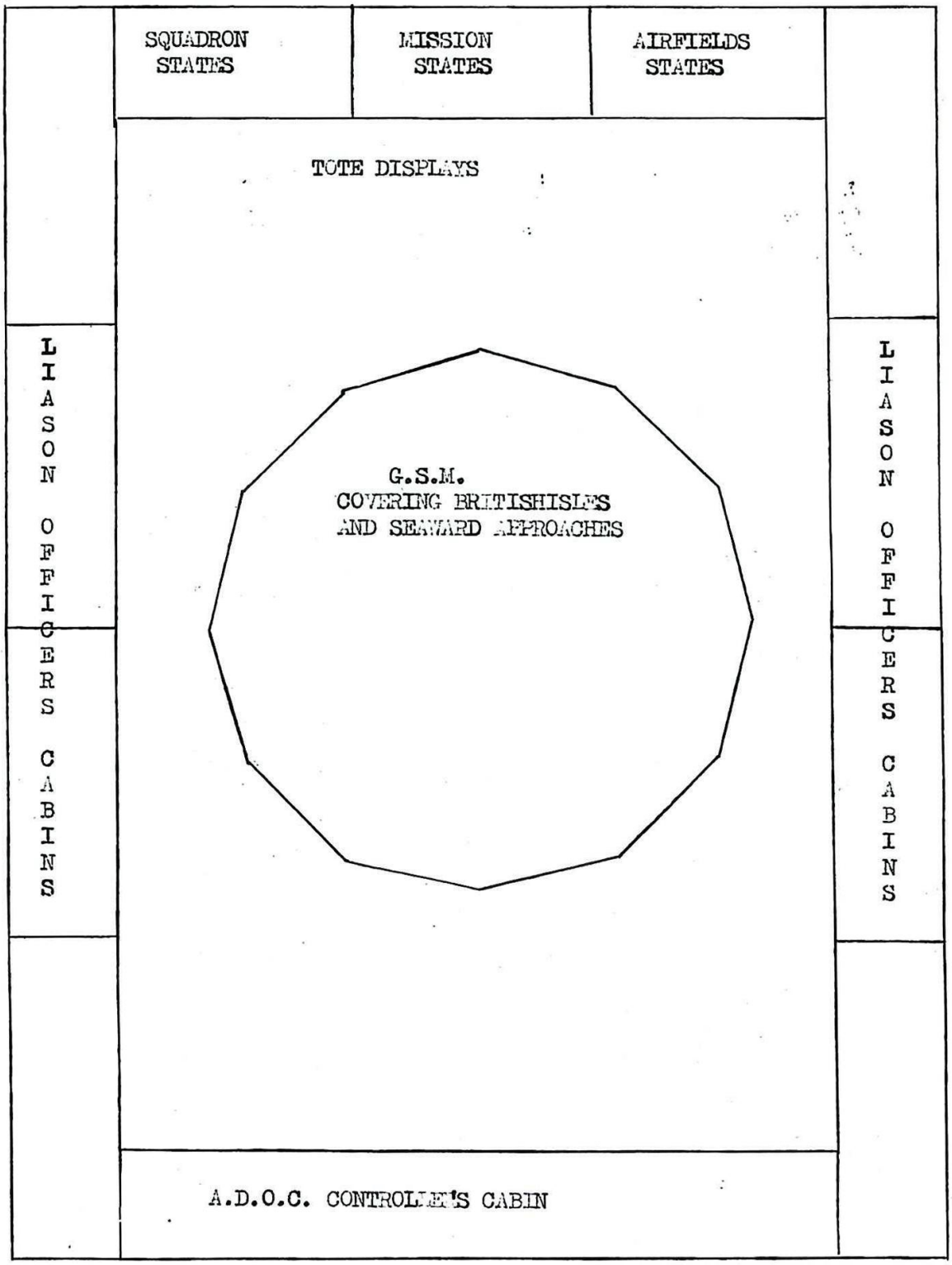
(d) Airfield States. Details of current airfield serviceability are passed by sector tote supervisors to the A.D.O.C. tote supervisor who is responsible for maintaining this display.

PERSONNEL AND DUTIES

7.6. The duties of plotters and tote operators employed in this operations room follow closely those carried out by corresponding personnel at S.O.Cs. (see Precis 6).

PROCEDURES AND EQUIPMENT

7.7. Display procedures and equipment employed at the A.D.O.C. are similar to those of a S.O.C. with slight variation in the tote displays. Details are given in the appropriate F.C. Proc. Inst.



AIR DEFENCE OPERATIONS CENTRE
FIG. 1.

SECTION III : THE CONTROL SYSTEM IN THE UNITED KINGDOM

PRECIS 8 : THE GROUND CONTROL INTERCEPTION STATION

INTRODUCTION

8.1. Function. Ground Control Interception (G.C.I.) stations are stratigically positioned centres from which fighter aircraft are directed to meet enemy attacks. These stations have considerable overland cover and sometimes seaward cover, provided by rotating-beam type radar. Use is made of this source of information, by the reporting organization, each G.C.I. station includes a reporting element (C.H.B.). No further mention will be made of the reporting responsibilities of G.C.I. stations in this precis.

8.2. Siting. G.C.I. stations are sited in the United Kingdom with the intention of:-

(a) Utilizing the greatest seaward cover attainable by the radar employed.

(b) Providing as far as possible, complete radar cover.

EQUIPMENT AND LAYOUT

8.3. Interception control at G.C.I. stations is made possible by:-

(a) Radar. The radar used provides a visual presentation of the plan positions, and heights of fighters and targets.

(b) V.H.F. R/T. Very high frequency radio-telephony (V.H.F. R/T) equipment is installed at G.C.I. stations and in all fighter aircraft. This equipment provides two-way communication between ground and air, and enables the pilot to be directed from the ground to intercept his target.

Radar

8.4. Radar at G.C.I. stations is designed to afford the maximum all round gapless cover and comprises:-

(a) Type 7 and 14 control radars (see Precis 11, paras. 4 and 6).

(b) Type 13 height finding radar(s) (see Precis 11 , para. 7).

8.5. The transmitters, receivers and aerial arrays of the various radars are situated near the operations buildings. Signals received are 'fed' to display consoles within the building.

V.H.F. R/T

8.6. A V.H.F. R/T set having (usually) 20 channels is carried in all fighters. Several of these channels are allocated solely for control use. Pilots can select the channel required by means of push-buttons.

8.7. Similarly, within G.C.I. stations each interception controller is provided with V.H.F. R/T facilities. He has a selection box giving (usually) 10 channels. He operates the transmitter and receiver by remote control (V.H.F. transmitter and receiver stations are usually situated a short distance from the G.C.I. stations).

8.8. Each V.H.F. channel in the fighter is lettered. Each V.H.F. channel at G.C.I. stations is numbered.

8.9. The use of multi-channel V.H.F. communication permits:-

(a) Rapid selection, both in the fighter and at the G.C.I. station of the control channel allotted by the control executive at the S.O.C.

(b) Several channels to be used at the same time to control several interceptions from one G.C.I.

(c) Changeover of channels when:-

(i) Communication fails on a particular channel.

(ii) Fighters are passed from one control to another (e.g. interception controller to sector fighter marshal).

Operations Room Layout (Fig. 1)

8.10. The chief controller at the G.C.I. station maintains supervision of the work of his fighter marshal and interception controllers. He occupies a cabin overlooking a display hall in which are the displays he requires. The fighter marshal occupies an adjacent cabin. Interception controllers occupy separate interception cabins. In selected G.C.Is. the fighter marshal is replaced by a sector fighter marshal who is responsible, not to the local chief controller, but directly to the control executive at the S.O.C.

Display Hall

8.11. The displays in the G.C.I. display hall are similar to those at the S.O.C. They are overlooked by the chief controller and the fighter marshal/sector fighter marshal. The displays are the:-

(a) G.S.M. This is similar to the sector G.S.M. but it displays a smaller area. The G.C.I. plotters receive the same broadcast from the C.C.F.P. as the sector plotters.

(b) Mission Tote. To permit rapid reference, the G.C.I. mission tote is divided into sections. A section of it is allocated to each cabin, including the fighter marshal's cabin, for the display of information applicable to the missions under control.

(c) Fighter Screen. This is a transparent vertical plotting screen and is used to display the progress of interceptions being carried out in the cabins. This interception picture is displayed by means of plastic "stick-on" arrows (see Precis 21).

(d) A.A. States Board. This is a replica of the one at S.O.C.

(e) Airfield States and Weather Board. These are replicas of those used at S.O.Cs.

(f) R/T Allocation Board. This display serves as a reminder to the chief controller of the frequencies available in fighters.

8.12. Chief Controllers Cabin. The chief controller and his assistant occupy a glass fronted cabin overlooking the displays. His equipment consists of:-

(a) Radar displays consoles - On these are displayed Types 7 and 14 radars.

(b) V.H.F. R/T facilities. These comprise a selection box, a microphone and a loud speaker.

(c) Intercommunication system - This is used for passing instructions to interception controllers.

8.13. Interception Cabins. Most G.C.I. stations have 3 interception cabins each known by a colour - red, yellow or green. Each cabin (Fig. 2) contains similar equipment comprising:-

(a) Display consoles:-

(i) Type 7 plan-position indicator (P.P.I.)

(ii) Type 7 height-range display (H/R)

(iii) Type 14 P.P.I.

(iv) Type 13 height display

(b) V.H.F. R/T equipment:-

(i) Channel selection box

(ii) Microphone (transmitter)

(iii) Loudspeaker (receiver).

(c) Intercommunication system. Liaison with the chief controller is effected in this manner.

(d) D/R Navigation Board. This is a perspex covered map covering an area of approximately 100 nautical miles radius around the station and is used in conjunction with navigational instruments to solve interception problems.

(e) Wall displays. These include:-

(i) Cabin G.S.M. This is a vertical perspex screen fixed on the wall in view of the interception controller. Hostile and unidentified tracks shown on the G.S.M. in the display hall are broadcast and displayed (with wax pencils) on this screen to enable the controller to associate the position of his target with a response on his radar screen.

(ii) Weather Board. This is similar to that in the display hall, it shows meteorological information affecting air navigation (e.g. wind direction and speed at various altitudes, air temperatures, barometric pressure at sea level etc.).

(iii) General Information Board. This is used to display information relative to the interception (e.g. type of fighters - call-sign - time airborne - parent airfield etc.).

(f) Tracing Table. Records of interception are plotted on tracing paper clamped over a map of the sector area. These records are used for subsequent analysis.

8.14. Fighter Marshal's Cabin/Sector Fighter Marshal's. The fighter marshal or sector fighter marshal occupies a cabin next to the chief controller and is provided with:-

(a) Radar Display consoles - These display types 7 and 14 radars.

(b) V.H.F. communication equipment

(c) Multiphone keyboard (see Para. 26)

(d) D/R Navigation board - (see Para. 15(c)).

8.15. R/T Monitoring Room. R/T channels in use at the G.C.I. station are monitored and a log is kept of communications between interception controllers and pilots.

PERSONNEL AND DUTIES

8.16. Chief G.C.I. Controller. The chief G.C.I. controller is responsible to the control executive for:-

(a) Tactical control of aircraft allotted to his G.C.I.

(b) The delegation of interceptions to interception controllers.

(c) Passing information regarding orders for control to interception controllers (e.g. gun restriction in force in G.D.As. etc.).

(d) Liaison with adjacent chief controllers on control matters (e.g. handover of fighters etc.).

8.17. Interception Controller. Is responsible to the chief G.C.I. controller for:-

(a) Carrying out the interceptions delegated to him.

(b) Ensuring the plotting of fighters under his control to the local fighter display.

(c) Handover of fighters to adjacent G.C.Is. as ordered by the chief controller.

8.18. G.C.I. Fighter Marshal. Is responsible to the chief G.C.I. controller for:-

(a) Control of fighters awaiting allocation to interception controllers or awaiting return to base under sector fighter marshal's control.

(b) Ensuring the plotting of fighters under his control to the local fighter display.

(c) Rapid handover of fighters to other controls as ordered by the chief controller.

NOTE: Each controller is responsible for the safety of aircraft under his control.
The sector fighter marshal is not a part of the G.C.I. organization.

8.19. Interception Crew. Each interception controller is assisted in his work by an interception crew. This crew consists of:-

(a) N.C.O. i/c. He is responsible to the interception controller for:-

(i) The efficiency and training of his crew.

(ii) Keeping a log of all watch activities.

(iii) Maintaining a log of interceptions.

(iv) Keeping the various wall displays up-to-date.

(b) P.P.I. Readers. The cabin layout is arranged so that the two radar P.P.I. displays (Type 7 and 14) are adjacent, with the control V.H.F. between. A plotter known as a P.P.I. reader sits at each display with the interception controller between. The P.P.I. reader at the display which the controller is using to carry out an interception, plots the tracks of fighter and targets at least one every minute, passing the details to the:-

(i) D/R navigator.

(ii) Recorder/tracer.

(iii) Local fighter screen plotter.

(c) Height Readers. Using Type 7 (H/R) and Type 13 displays the height readers help the controller informed of:-

(i) actual heights of targets and fighters in the early stages of an interception.

(ii) comparative height of target and fighter during closing stages of the interception (e.g. "target 1,000 below fighter").

(d) D/R Navigator. He receives plots on tracks of both fighter and target aircraft from the P.P.I. reader, together with heights from height readers. With this information, meteorological information and the use of navigational instruments, he is able to compare:-

(i) The course and indicated air speed of the target (i.e. that shown on the instruments in the enemy planes).

(ii) The approximate position of the target, during periods when radar indications fade from the displays. He does this by a method of navigation known as 'dead reckoning' (D/R).

(iii) The fighters distance and course to steer to its base at any time.

(e) Recorder/tracer. The recorder/tracer, on tracing paper, received from the various crew members noting:-

(i) Time

(ii) Course alterations ordered by the controller.

(iii) Sightings by fighter pilots.

(iv) Heights (actual and comparative).

(v) Any other data relative to the interception progress.

(f) Cabin G.S.M. Plotter. He plots selected tracks (hostile or unidentified) on the cabin wall G.S.M.

8.20. Chief G.C.I. Controller Assistant. This assistant's main duties are:-

(a) To keep a log of all instructions received and passed by the chief controller.

(b) To operate a telephone keyboard and deal with calls of a routine nature.

8.21. Fighter Screen Plotter. One plotter connected to each cabin by telephone reproduces, by means of symbols, tracks of fighter and targets on the reverse of the transparent vertical screen.

8.22. Fighter Screen Teller. Seated on the balcony overlooking the displays, he tells all tracks from the fighter screen to the fighter table at the S.O.C.

8.23. Cabin G.S.M. Broadcast Teller. Seated on the balcony overlooking the G.S.M. he passes (over broadcast lines to the cabins) information on selected tracks indicated by the chief controller.

8.24. R/T Monitor. Personnel are employed to monitor G.C.I. R/T channels and keep a log of messages passed.

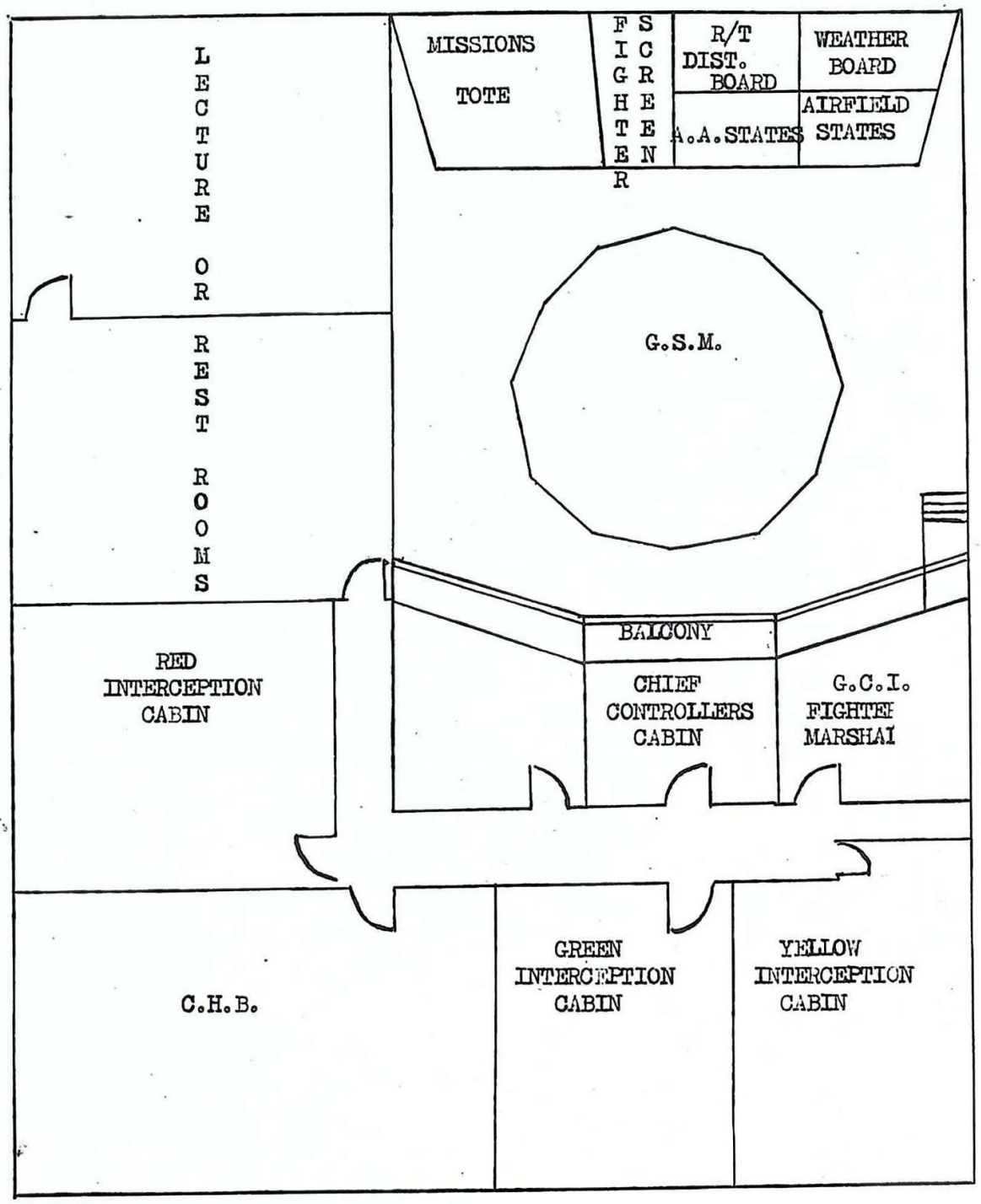
8.25. Other Personnel. All other duties in the display hall conform closely to those carried out by corresponding personnel at the S.O.C. (see Precis 6).

COMMUNICATIONS

8.26. Keyboards. Key personnel within the G.C.I. stations (e.g. chief controller, sector/G.C.I. fighter marshal, floor supervisor etc.) are provided with multi-line keyboards, which provide direct contact with those to whom rapid and repeated contact is necessary. Lines from these keyboards also afford contact with the stations operations P.B.X. switchboard and to the normal G.P.O. services for calls of a routine nature.

8.27. Intercommunications. The chief controller controls the use of the intercommunication system by which rapid contact is made between himself, interception controller and fighter marshal.

G.C.I. OPERATIONS BUILDING LAYOUT (FIG. 1)



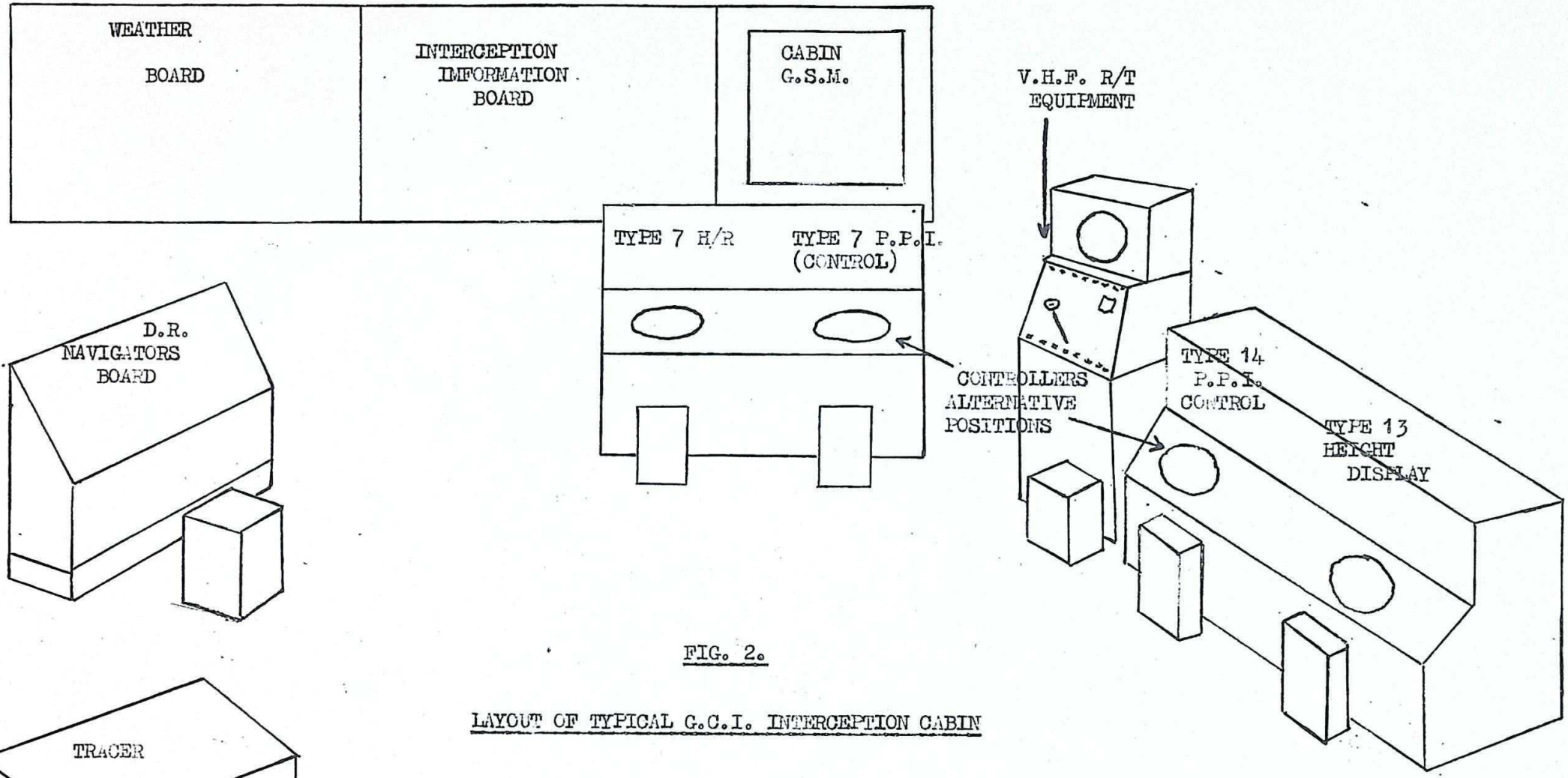


FIG. 2.

LAYOUT OF TYPICAL G.C.I. INTERCEPTION CABIN

SECTION III : THE CONTROL SYSTEM OF THE UNITED KINGDOM

PRECIS 9 : ANTI-AIRCRAFT ARTILLERY

INTRODUCTION

9.1. The gun defences of the United Kingdom together with fighter aircraft comprise the weapons of active air defence. It is only by skilful co-ordination of these weapons that attacks may be countered to the maximum advantage of the defending forces.

9.2. Anti-aircraft artillery defences are of two kinds - heavy A.A. and light A.A.

9.3. The functions of A.A. artillery are to:-

(a) Destroy enemy aircraft, and

(b) Prevent accurate attack.

9.4. The following paragraphs describe the organization, equipment, deployment, and operation of A.A. defences, the control orders used to achieve co-ordination of the operations of fighter and A.A. artillery are set down and the methods of displaying these orders are described.

ORGANIZATION IN THE UNITED KINGDOM

9.5. A.A. Command is organized in the following way:-

(a) Command Headquarters is responsible for policy and planning

(b) Groups of which there are five, cover the U.K. each has under Command a varying number of brigades.

(c) Brigades are made up of a varying number of H.A.A. and L.A.A. regiments.

(d) Regiments are of three kinds:-

(i) Heavy A.A.

(ii) Light A.A.

(iii) Light A.A./Searchlight

HEAVY A.A. ARTILLERY

9.6. Heavy A.A. guns are capable of engaging enemy aircraft flying at heights between 2,000 feet and the operational ceiling of the gun. Each H.A.A. regiment mans a number of gun positions up to a maximum of 6 each of 4 guns.

9.7. The Gun Position. Each H.A.A. gun position is equipped with:-

(a) Four guns, which are fitted with automatic loading, fuze setting and firing gear. Some types are remotely controlled.

(b) Radar equipment which consists of:-

(i) Tactical control radar - to give warning of approach of targets, and give turn for selection of suitable targets

(ii) Fire control radar - which "lock on" to the selected target and feeds present position data to a

(c) Predictor (electronic) used for rapid determination of the future point of aim of the guns.

9.8. Deployment. Heavy A.A. guns are deployed to defend areas which the enemy are most likely to attack. These are known as Gun Fire Areas (G.F.As.).

9.9. Operation of H.A.A. Guns.

(a) Control orders for H.A.A. guns are originated by Sector Controllers, advised by their A.A. Controllers, by the H.A.A. Executives to Anti-Aircraft Operations Rooms (A.A.O.Rs.).

(b) Army tellers in the C.C.F.P. pass relevant E.W. information of the air picture to A.A.O.Rs. where it is displayed on a (G.S.M.) plotting table. This information is the only source of target identification for the gun positions.

(c) A.A.O.R. tellers relay relevant portions of the air picture to gun positions. (These tellers are called Duty Officers Assistants (D.O.As.))

(d) An A.A.O.R. directs the activities of the many gun positions forming a G.F.A. In large G.F.As. there may be more than one A.A.O.R.

(e) In many sectors there are several G.F.As. and therefore several A.A.O.Rs.

9.10. Gun Characteristics

(a) L.A.A. guns are designed for use against targets flying below 2,000 feet.

(b) Guns have high rate of fire and are power operated.

9.11. Deployment. L.A.A. guns are deployed around vulnerable points (V.Ps), e.g. airfields, Radar stations, factories etc.

9.12. Observations Posts (O.Ps.) A ring of O.Ps. is sited about 5,000 yds. forward of the outer guns to alert the gun crews and to recognize low flying aircraft. They pass back to the gun positions details of the attacking force (i.e. identity, strengths, direction of approach etc.)

9.12A. Early Warning. Early warning is passed to L.A.A.C.C. (Light A.A. Control Centres by a broadcast off the Rats table and G.S.M. at the S.O.C. by the L.A.A. Executive.

9.13. Operation of L.A.A. Guns

(a) Control orders for use of L.A.A. guns are originated by Sector Controller, advised by their A.A. controllers and are passed by the L.A.A. Executive to the Light Anti-Aircraft Control Centre (L.A.A.C.C.) normally accommodated in a vehicle.

(b) These control orders are transmitted by R/T from the L.A.A.C.C. to the individual guns.

LIGHT A.A./SEARCHLIGHTS (S.L.) ARTILLERY

9.14. Searchlights are deployed with some L.A.A. guns to enable them to operate effectively at night by illuminating low-flying enemy aircraft.

9.15. Equipment

(a) Guns - as for L.A.A. regiments

(b) Searchlights - each troop has a number of radar controlled searchlights and a number, manually operated, which follow and support the radar controlled ones.

9.16. Deployment

(a) Guns are deployed around V.Ps.

(b) Searchlights are used instead of observation posts, their object being to illuminate the target before it comes within range of the guns.

9.17. Operation of Gun Positions. L.A.A. guns deployed with searchlights are controlled in the same manner as guns deployed without them.

9.18. Operation of Searchlights.

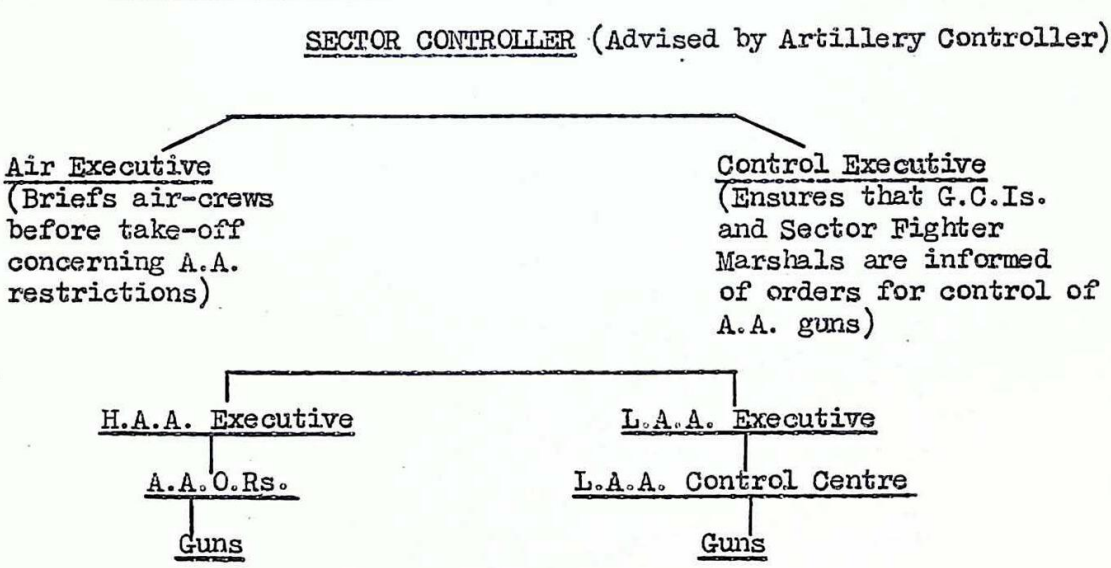
(a) Searchlight positions are alerted by the L.A.A.C.C. from which the controller directs their search for targets

(b) The radars detect the target and when "locked on", searchlights beams are exposed.

(c) Only when the target is illuminated by radar controlled searchlights, do the manually operated searchlights expose.

CONTROL OF A.A. GUNFIRE

9.19. Levels of Control



9.20. Control Orders for H.A.A. Guns. The following H.A.A. fire control orders are used:-

(a) Guns Free. This order indicates that fire may be opened at aircraft other than those recognized as friendly within the limitations imposed (e.g. "guns free above two zero").

(b) Guns Tight. This order indicates no fire to be opened on any aircraft unless that aircraft is recognized as hostile or has committed a hostile act, and only if friendly aircraft are not endangered.

(c) Hold Fire. This is an emergency order used to indicate that guns may not fire under any circumstances regardless of enemy action, until the order "Cancel Hold Fire" is received.

(d) Cancel Hold Fire. On receipt of this order guns revert to the state in force prior to the imposition of "Hold Fire".

9.21. Definitions. Terms used in para. 20 are defined:-

(a) Recognition. The term "recognition" is the determination by any means of the friendly or enemy character or individuality of another.

(b) Identification. The indicated by any act or means of ones own friendly character or individuality.

(c) Hostile Acts. An aircraft commits a hostile act if:-

(i) It attacks

(ii) It dives directly at an objective

(iii) It makes a direct low-level approach to an objective.

9.22. Areas of Restriction. Large gun fire areas (G.F.As.) are divided into planned control areas of convenient size.

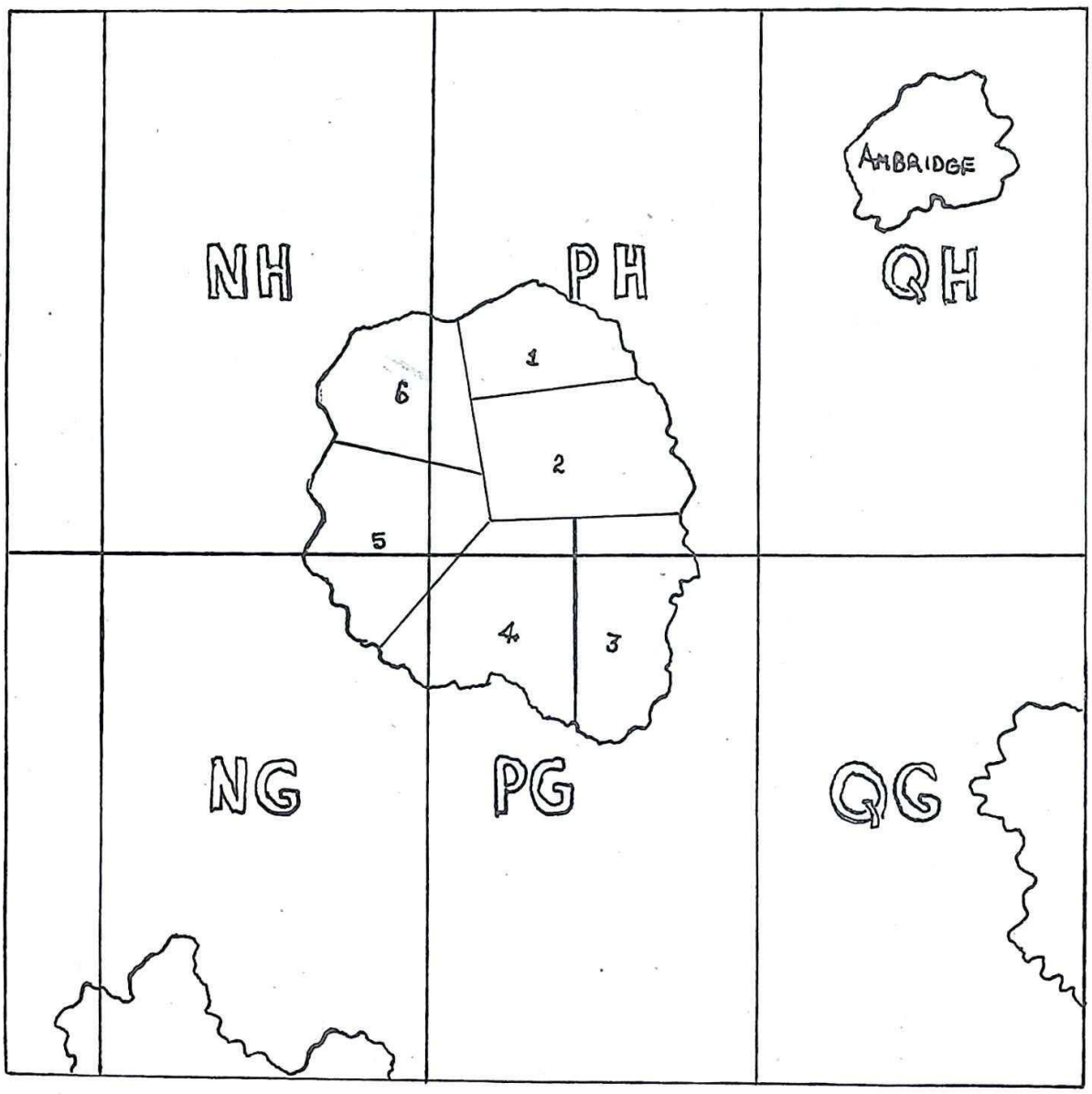
9.23. G.S.M. and Fighter Display. A red line painted on these displays indicates the limits of shell fire of the G.F.As.

9.24. H.A.A. Display Boards (Fig. 1). These vertical boards are provided at S.O.Cs. and G.C.I. stations and show the shell fire areas within and adjacent to the sector. Each control area has "slats" inserted and display is effected by use of "hook-on" equipment. The control order is indicated by means of a colour code. For further details of equipment and procedures see appropriate Fighter Command Control Procedure Instructions.

9.25. Control Orders for L.A.A. Guns. The following table sets out the orders given for the control of L.A.A. guns and the action taken by the gunners in differing circumstances.

S.O.C. Order	L.A.A. Observation Posts Report	Action by Guns
(a) L.A.A. Guns Tight	Hostile	Fire unless/until gun No. 1 subsequently recognizes target as friendly
	Doubtful	Do not fire unless target attacks
	Friendly	" "

S.O.C. Order	L.A.A. Observation Posts Report	Action by Guns
(b) L.A.A. Guns Free	Hostile	Fire unless/until gun No. 1 subsequently recognizes target as friendly
	Doubtful	" "
	Friendly	Do not fire unless target attacks
(c) L.A.A. guns Emergency (L.A.A. "Hold Fire" order)	Hostile) Doubtful) Friendly)	All fire must stop



H.A.A. STATE BOARDS

FIG. 1.

SECTION IV : RADAR

PRECIS 10 : RADAR PRINCIPLES AND BASIC TECHNIQUES

Introduction

10.1. Definition. Radar (radio detection and ranging) is a means whereby positions of objects can be determined, regardless of visibility, from a single observation point and without the active co-operation of those objects.

The "Echo" Principle

10.2. Sound Echoes. A sound echo is caused by disturbing the air (e.g. by shouting). The disturbance creates sound waves that travel away until they meet a suitable reflecting surface, from which they return and are heard as a weaker replica of the original noise. These waves travel at a constant speed of 1,100 feet per second.

10.3. Radio Echoes. The echo principle is used in radar where objects are detected by radiating energy in waves. Radar waves, however, travel at 186,000 land miles per second equivalent to 162,000 nautical miles per second or 300,000,000 metres in one second.

Range Determination Using the Echo Principle

10.4. The fact that sound and radar waves travel at constant speeds makes it possible to calculate distance using the "echo" principle. The following examples show how this is done:-

(a) "Sound" ranging

(i) A shout produces sound waves which travel outwards, strike a reflecting surface (e.g. a hillside) and return to their source.

(ii) A stop watch is used to measure the time that has elapsed between the original noise and the returning echo.

(iii) The distance in feet to the hillside is equal to half the total time elapsed in seconds, multiplied by the speed of sound in feet per second. (e.g. Assume total time elapsed is 48 seconds)

$$\text{then distance} = \frac{48}{2} \times 1100$$

$$= 26{,}400 \text{ ft.} = 5 \text{ miles.}$$

(b) Radio ranging

(i) A transmitter produces powerful pulses of energy, the waves of which travel outwards strike a reflecting surface (an aircraft) and return to a (local) receiver.

(ii) Radio waves travel too quickly to be measured mechanically. Substituted for the stop watch is an electronic device known as a cathode-ray tube (C.R.T. para. 6).

(iii) The distance to the reflecting object is equal to half the time taken by a single pulse to travel to the reflecting object and back, multiplied by the speed of radar waves.

(iv) Because the speed of radar waves is constant, distance is directly proportional to time. The C.R.T. which is a time measuring device, may also therefore be regarded for out present purpose, as a distance measuring device.

Cathode Ray Tubes

10.5. There are many types of C.R.T., the display of the T.V. receiver being, perhaps, the best known. The two examples described in the following paragraphs are used throughout the radar stations of the C. & R. system. They are:-

(a) The electrostatic (range) tube

(b) The electromagnetic (Plan-position indicator - P.P.I.) tube.

10.6. Electrostatic C.R.T. (Fig. 1). This C.R.T. comprises:-

(a) Fixed electrodes which produce an invisible electron stream and focus it to a fine point on the screen.

(b) A screen coated with a fluorescent substance which glows when the electron stream strikes it, showing as a spot of light.

(c) Deflection plates:-

(i) Horizontal ("X" plates). Voltages applied to these plates deflect the spot from left to right at the required constant speed. Rapidly repeated deflections make the moving spot appear as a line of light. This line is known as the "time base".

(ii) Vertical ("Y" plates). Incoming signals are detected at various time intervals as the spot moves from left to right. These signals, fed to the "Y" plates, cause a deflection (usually arranged to be downward) of the time base. This deflection is known as a "response".

10.7. Operation

(a) Synchronization. The transmitted pulse and the spot commence at the same time.

(b) Range. The time taken by the spot to move across the screen is arranged to be equal to the time taken by the pulse to travel twice that distance (e.g. while the pulse and its echo travel 200 miles, the spot traces a distance representing 100 miles.)

(c) Calibration. As the spot travels at a constant speed and represents time, and therefore range, the time trace can be electronically subdivided at 5 or 10 mile intervals. A range scale is marked off against these divisions and fixed above the time trace (Fig. 2).

(d) Sequence of Events

(i) The pulse is transmitted

(ii) The spot starts across the screen simultaneously

(iii) The pulse strikes an aircraft and returns

(iv) The returned pulse is fed as a voltage to the "Y" plates causing the spot to be deflected downwards thus making a response.

(v) The response is associated with a range on the range scale to reveal the distance of the detected object.

10.8. Electromagnetic C.R.T. (Fig. 3). This C.R.T. comprises:-

(a) Fixed Electrodes which produce an invisible electron stream.

(b) Focus Coil. The electron stream is focussed into a fine spot on the screen by adjusting the current flow in a fixed coil fitted around the neck of the C.R.T.

(c) Deflection Coils:-

(i) A pair of rotatable coils around the neck of the C.R.T. are used to deflect the electron stream radially from the centre of the screen. This is done at such short intervals as to make the spot appear as a line of light ("time-base").

(ii) The coils are turned mechanically in synchronization with a rotating aerial so that the time base points in the same direction as the transmitted beam.

10.9. Operation. The basic principle of the electrostatic C.R.T. are embodied in the electromagnetic C.R.T.:-

(a) Synchronization - as para. 7(a).

(b) Range - as para. 7(b).

(c) Calibration.

(i) By operating a switch, the rotating time-base can be electronically divided by brightening it at 5 mile intervals.

(ii) This brightening of the time-base, makes each 5-mile division appear as a spot of light, and as the time base rotates, a series of equidistant concentric circles is painted on the screen.

(iii) To ensure accuracy these circles are checked periodically against marks marked on perspex masks fitted over the screen.

(d) Sequence of Events. With this type of C.R.T. a common transmitting and receiving aerial is used (see para. 16).

(i) Pulses are transmitted as the aerial rotates and a spot moves from the centre of the tube in the direction which the aerial rotates.

(ii) The time-base rotates in synchronization with the turning aerial.

(iii) At a certain range and bearing pulses are reflected from an object.

(iv) The receiver is designed so that the reflected pulses when received cause a brightening of the time-base, "painting" a small arc or spot (see note) on the

fluorescent screen, thus indicating the position of the object relative to the ground (Fig. 4).

(v) The plan position of a response can be read by the use of a gridded mask, placed correctly orientated, over the face of the screen (Fig. 5).

NOTE: The shape of the response depends on the type of radar employed (e.g. Type 7 paints a 12° arc - Type 14 a spot).

10.10. Ground Ray and Permanent Echoes. Pulses are reflected from objects in the vicinity of a radar station (e.g. high buildings, hills etc.). This causes a mass of responses to appear on the time-base usually from 0 to say 8 miles and a number of permanent responses at greater ranges dependent on the local topography and the height of the lowest angle of radiation from the station.

(a) Advantage. Certain permanent echoes (P.Es.) are selected when the station is working at peak performance. Note is taken of their amplitude (a measurement of the strength of the response) and is subsequently used as a yardstick for checking station performance.

(b) Disadvantage. Tracking aircraft at close range is difficult or impossible on certain stations, due to aircraft echoes merging with P.Es.

Methods of Wave Propagation

10.11. Radar stations may achieve their coverage either by "floodlight" or "searchlight" radiation:-

(a) "Floodlight" stations have fixed aerials and the zone covered is constantly energized.

(b) "Searchlight" stations obtain full azimuthal cover by concentrating the radiation into a narrow beam (see para. 18) and rotating the aerial through 360° in azimuth.

Direction Finding

10.12. Floodlight Station. In order to determine the bearing of responses, this type of station has two component of its receiver aerial set at right angles to one another. The bearing is obtained by relating the strengths of the signals received by the two components. The instrument that examines this relationship is called a Goniometer.

10.13. "Searchlight" Station. Bearings are obtained on "searchlight" type stations by:-

(a) Aligning and synchronizing rotation of aerial and time-base on the C.R.T.

(b) Correctly orientating the aerial and time-base by reference to a bearing rose around the outer edge of the electromagnetic (plan-position) tube.

(c) An imaginary straight line from the station through the middle of the response to the bearing rose indicates the bearing.

Height Finding

10.14. There are two methods of obtaining heights of aircraft by radar.

(a) Direct height reading from the C.R.T. Display, (Type 13) known as a height range indicator (H.R.I.) of equipment designed solely for height determination (see Fig. 6).

(b) The aerial systems of certain types of radar (e.g. Type 7, C.H.) are adapted for height finding as well as finding bearings. Heights are determined by comparing signals, received by two aerials, at different heights, either:-

(i) By use of a goniometer (C.H.), or

(ii) By visual comparison of signal strengths (Type 7)

Radar stations using these methods, each have a specially prepared height calculation chart.

Radar Aerials

10.15. Propagation of Radio Waves. Propagation of radio waves is achieved by either:-

(a) A Dipole. This is made of copper (tube or wire) cut to a specific length, usually approximately half the wavelength of the station. Dipole aerials are used by "metric" type stations (e.g. C.H., G.C.I.). The properties of a dipole are such that it will radiate (and receive) well at right angles to its length, but negligibly along its axis.

(b) Reflector and Waveguide. This method is used by "centimetric" type stations. Radio energy from the transmitter passes, via a waveguide (hollow length of copper tube rectangular in section) into a curved reflector, which directs the energy outwards in a narrow beam. This type of aerial is used both for transmitting and receiving (see para. 16). Returning energy ("echoes") are received by the reflector and pass via the waveguide to the receiver.

10.16. Common Aerial. By a system of alternate switching, a single aerial array can be used for both transmitting and receiving, this means:-

(a) That whilst the transmitter is passing a pulse of energy to the aerial, the receiver is cut off from the aerial.

(b) In the intervening space between transmitted pulses, the receiver is switched to the aerial. As the operation is very rapid (faster than the eye can detect) the time-base does not flicker but appears as a steady line.

10.17. Stacks and Bays. Arranging dipoles in stacks (one above the other) and in bays (a number of adjacent stacks) has the effect of concentrating the beam vertically and horizontally.

10.18. Reflectors. Reflectors used on radar aerials act in the same manner as reflectors on car headlamps and when in operation behind dipoles:-

(a) Transmission is increased in the forward direction and back-radiation is reduced.

(b) Reception is increased in the forward direction.

10.19. Reflectors are in two main categories - tuned and untuned. Tuned reflectors (i.e. as used in C.H. stations) are usually lengths of copper wire or tubing cut slightly longer than the dipole. Untuned reflectors may be of wire mesh, a solid metal shield, or aluminium rods arranged in a curved shape.

Producing the Plot

10.20. Ranges and bearings of detected objects are converted into geographical references ("GEOREF" Precis 16) to facilitate the passing of this information from reporting source to user. This reference is known as a "Plot". Plots are produced by the following manner:-

(a) By automatic calculator. Range and bearing obtained by the radar operator are "fed" to an automatic calculator which produces the "plot" as a geographical reference to electronic display.

(b) By direct plotting. Plots can be read directly from a "plan position indicator". This involves:-

(i) The fitting of a perspex mask over the screen of an electromagnetic tube. This mask shows the grid graticule and a map of the area covered by the stations radar (see note).

(ii) An operator sitting centrally to the screen who reads plots indicated by the middle or the inner edge of the responses.

NOTE: The zero of the time-base (the stations' pin-point) can be moved to any position on the screen, thus affording a greater screen area in a required direction. This is known as "off-centering". The mask must be etched accordingly.

(c) Manual Conversion. This method is used whenever those described previously are not practicable.

(i) The range and bearing of an aircraft from the station are obtained by reading off from range scale.

(ii) A map of the stations "plotting area", bearing the grid graticule, shows the stations' pinpoint and around it is orientated a compass rose. A ruler bearing a range scale points at the stations' pinpoint, the point of zero range. The ruler is used to lay off the bearing as indicated by the compass rose, and range as shown on its scale.

(iii) The position obtained is now told as a "plot".

THE ELECTROSTATIC C.R.T.

The Electrodes (Static) which produce and control the electron stream

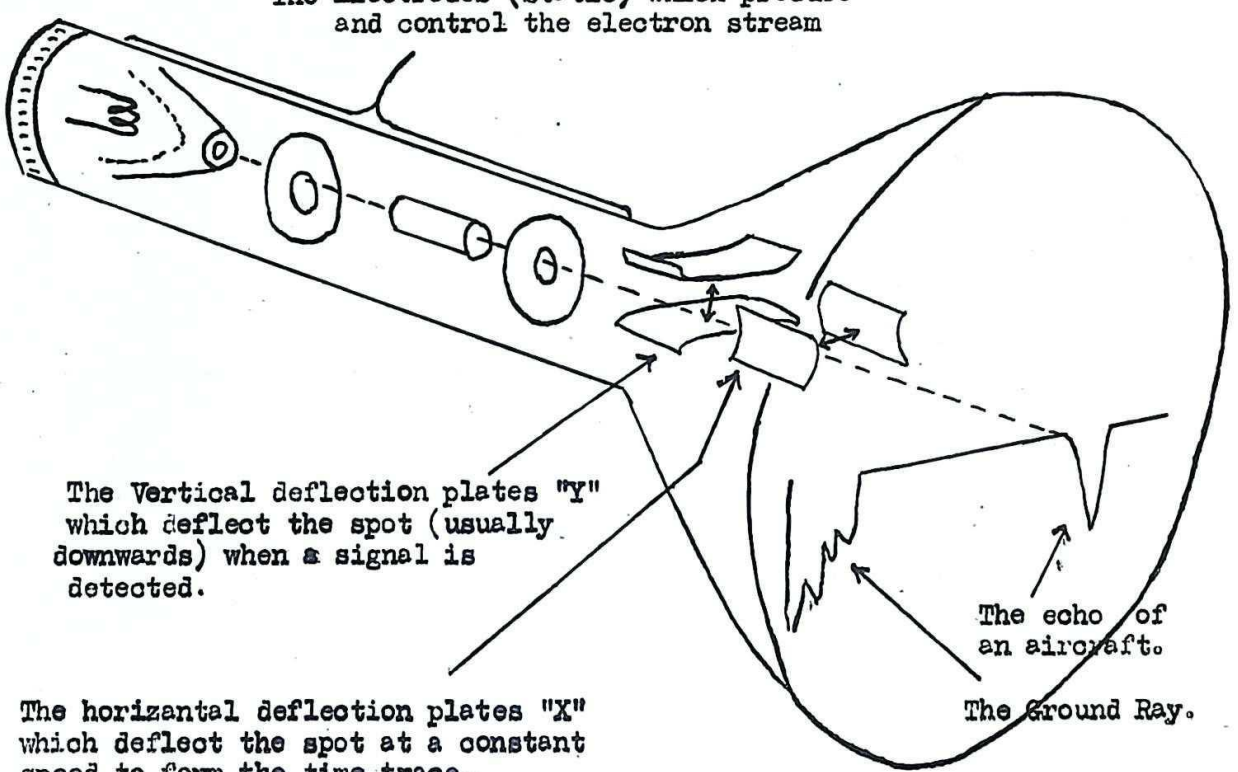


FIG. 1.

SCREEN OF C.R.T.

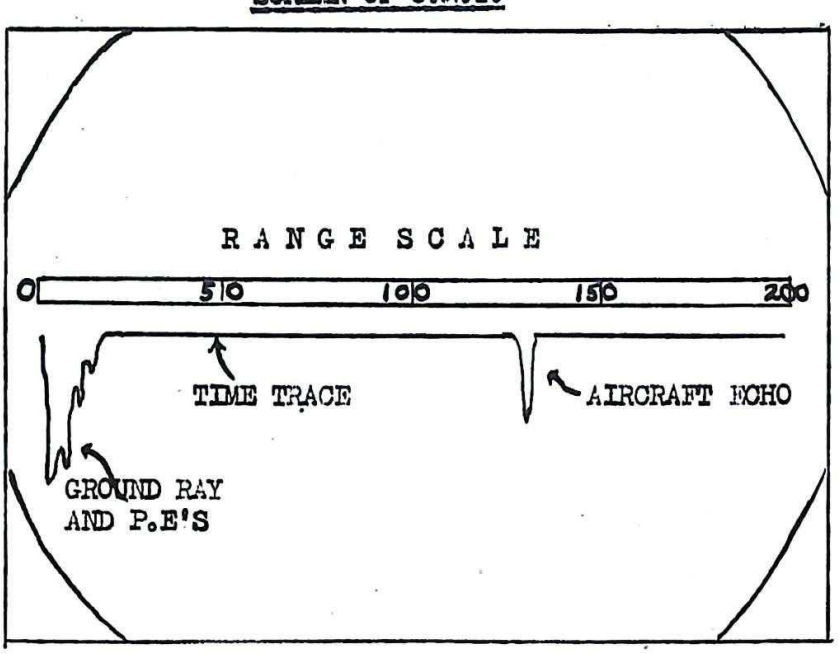


FIG.2

THE ELECTROMAGNETIC C.R.T.

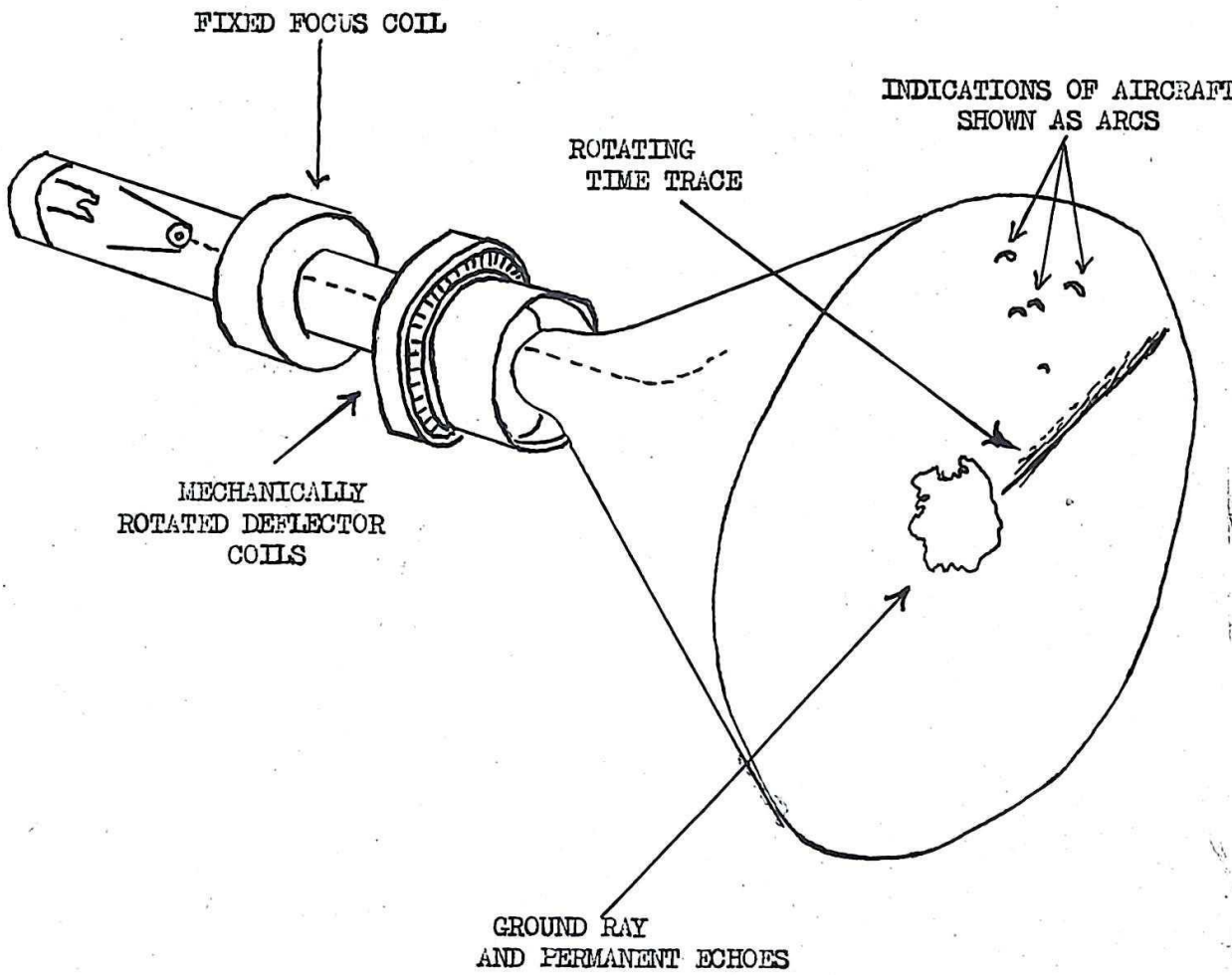
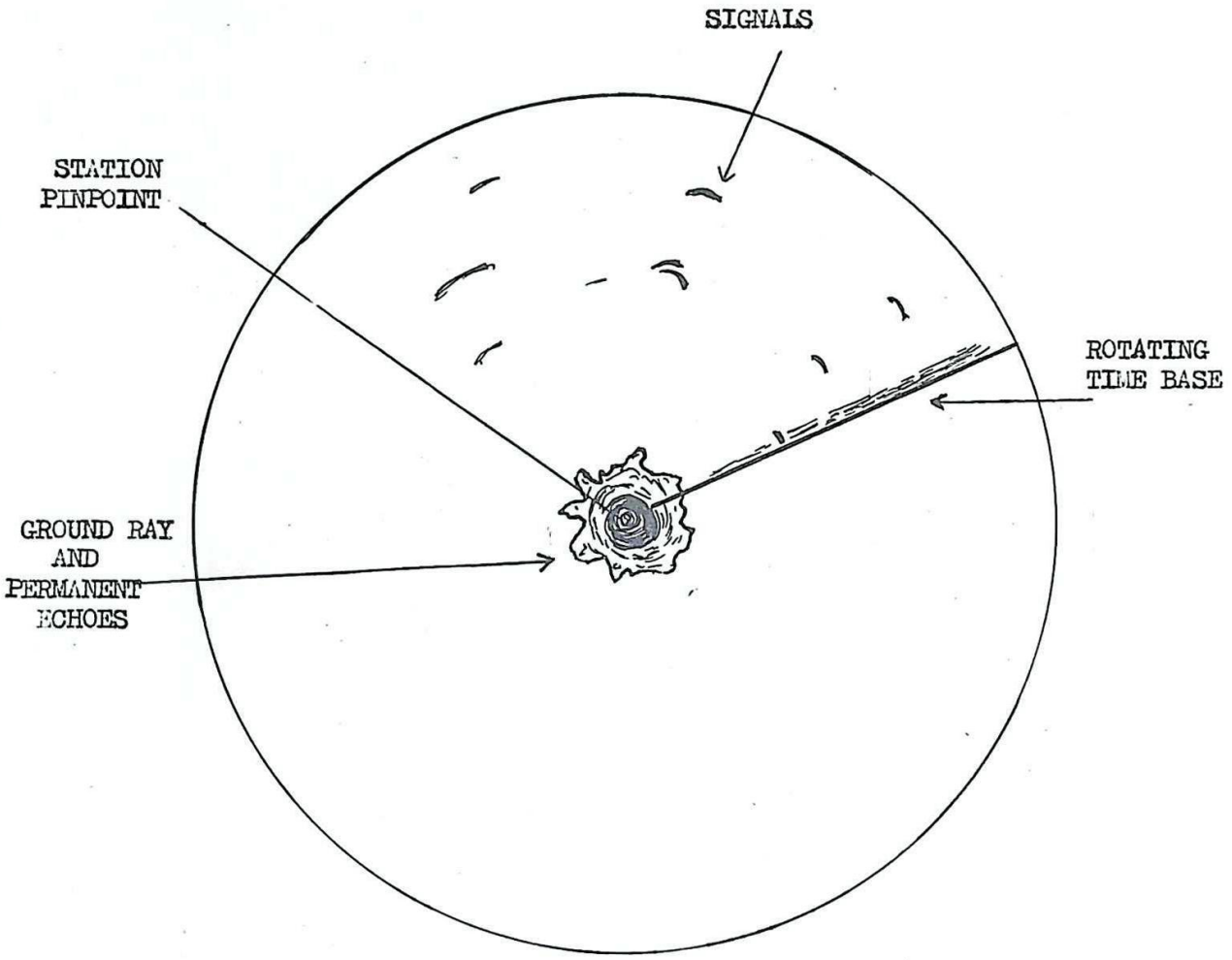
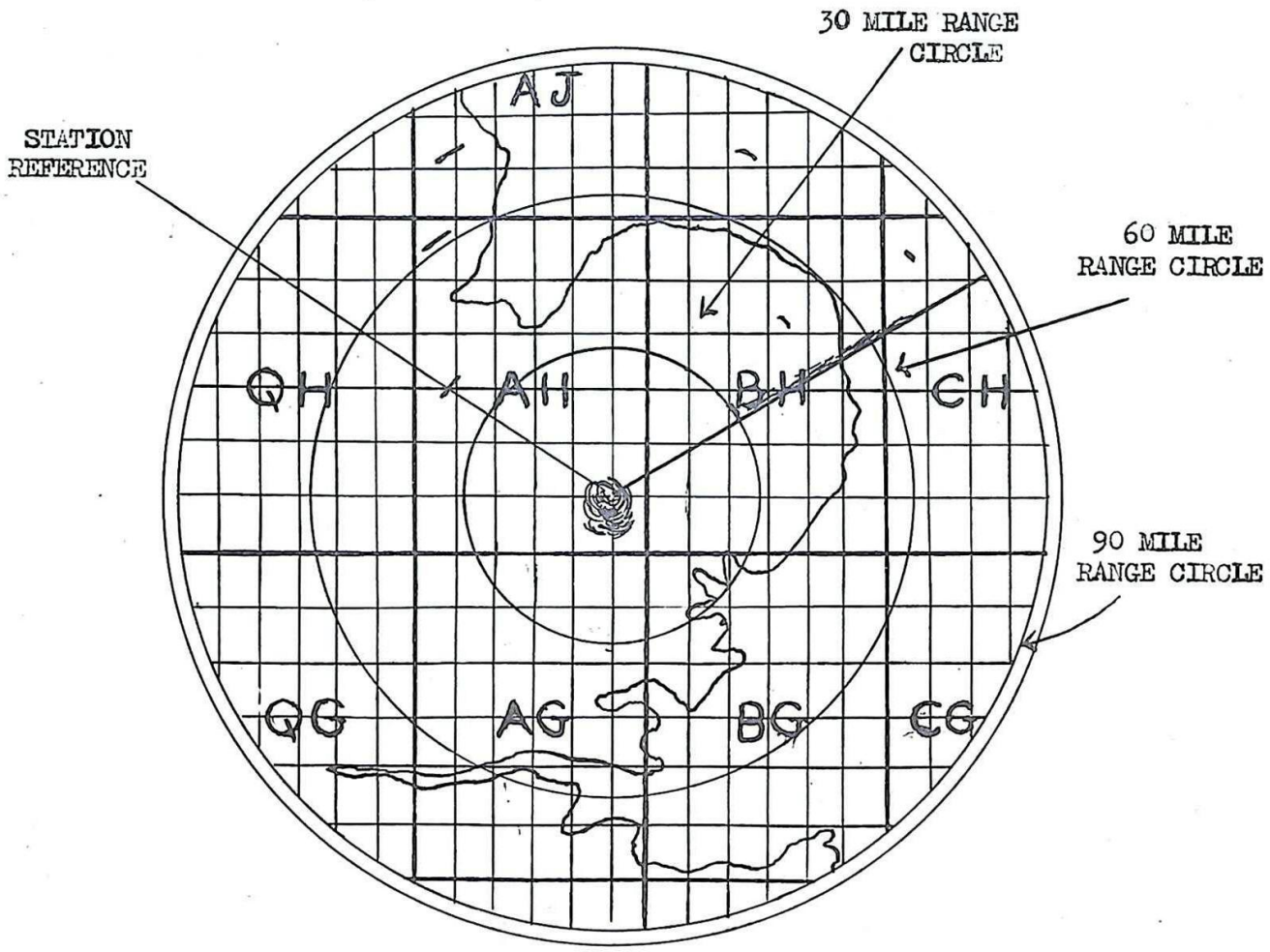


FIG. 3.



ELECTROMAGNETIC C.R.T. SCREEN(FIG. 4.)



PLAN POSITION INDICATOR(FIG. 5)

HEIGHT RANGE INDICATOR (H.R.I.) SCREEN

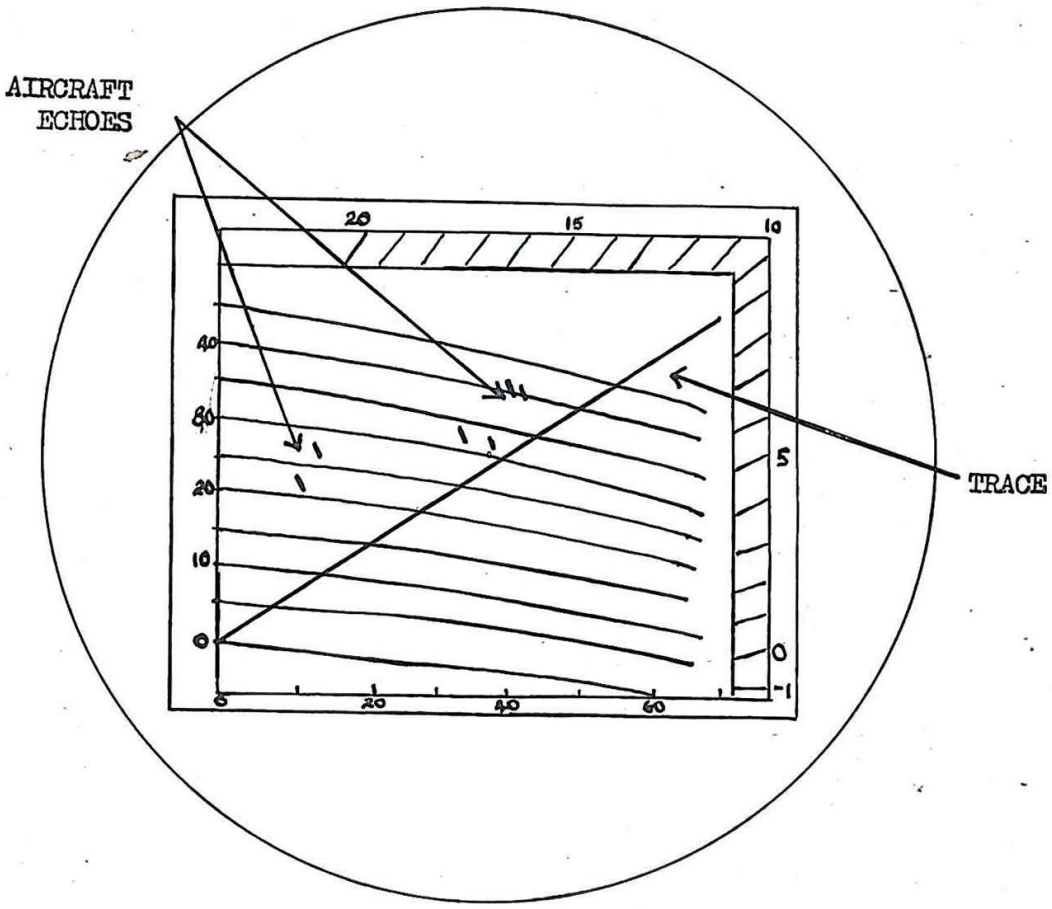


FIG.6.

SECTION IV : RADAR

PRECIS 11 : RADARS

Introduction

11.1. To prevent an enemy attack by air or sea from catching our defences unawares, a "chain" of radar stations has been set up throughout the United Kingdom. These stations are deployed in such a way as to:-

(a) Provide the maximum cover possible.

(b) Provide a means of controlling airborne fighters.

11.2. These radars include:-

(a) Types which fulfil a reporting function only.

(b) Others which are intended primarily for fighter control which are, nevertheless used for reporting.

11.3. Gapless cover is sought by:-

(a) Positioning stations of any one type so that their respective zones of horizontal cover overlap considerably.

(b) Positioning various types of radar with differing vertical cover, sufficiently close together to permit a degree of overlapping in the vertical plane.

Types of Radar in Current Use

11.4. The following paragraphs give a brief description of the various radars in current use which have a security classification of "Restricted". Other, secret, radars are described in Precis No. 26, 27, 28 and 29.

11.5. Type 1 or Chain Home (C.H.) Stations. Present Types stations are a development of the original "long-wave" floodlight stations.

(a) Function. Reporting the movement of aircraft to long range at medium and high altitudes.

(b) Site. Usually sited on, or near the coast.

(c) Aerials. Separate fixed aerials are used for transmitting and receiving (Figs. 1 and 2). Radiation is widespread in a "floodlight" pattern with:-

(i) Horizontal cover between 60°-70° on each side of the "line of shoot" (this is the direction of maximum radiation, at right angles to the transmitting array - (Fig. 3)

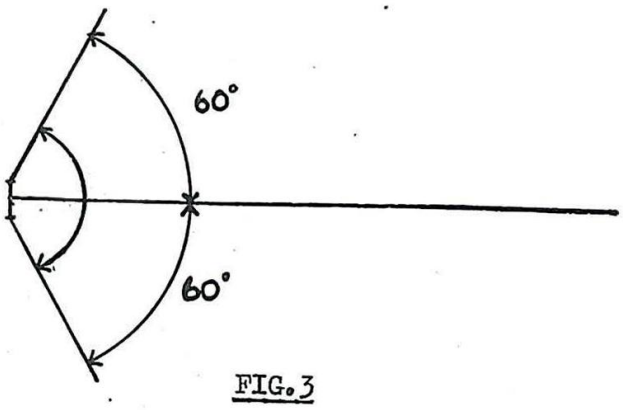


FIG.3

(ii) Continuous cover above the lowest limit of detection. This is achieved by the use of two aerial systems ("main" and "gap filler"). Vertical radiation is in the shape of lobes, each system having its own lobe pattern (Fig. 4). Either system may be selected by the operator as required.

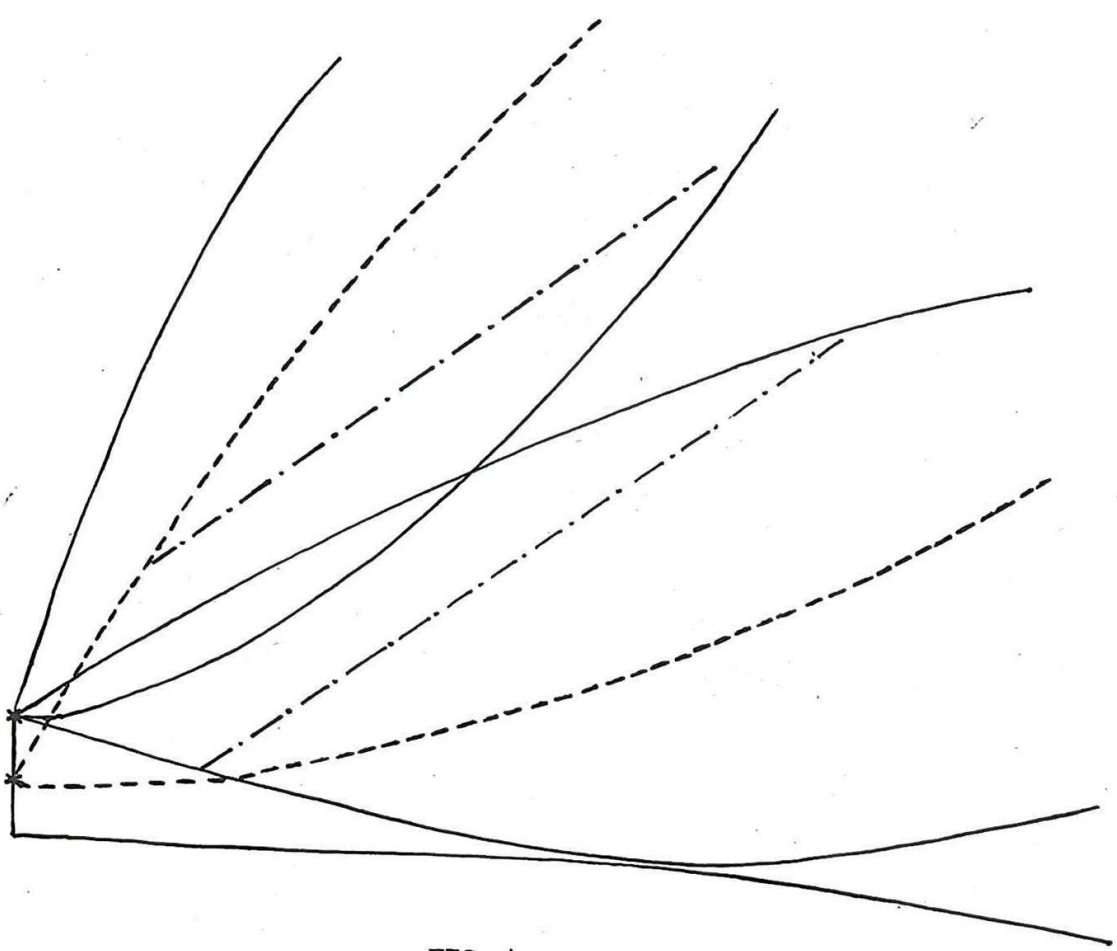


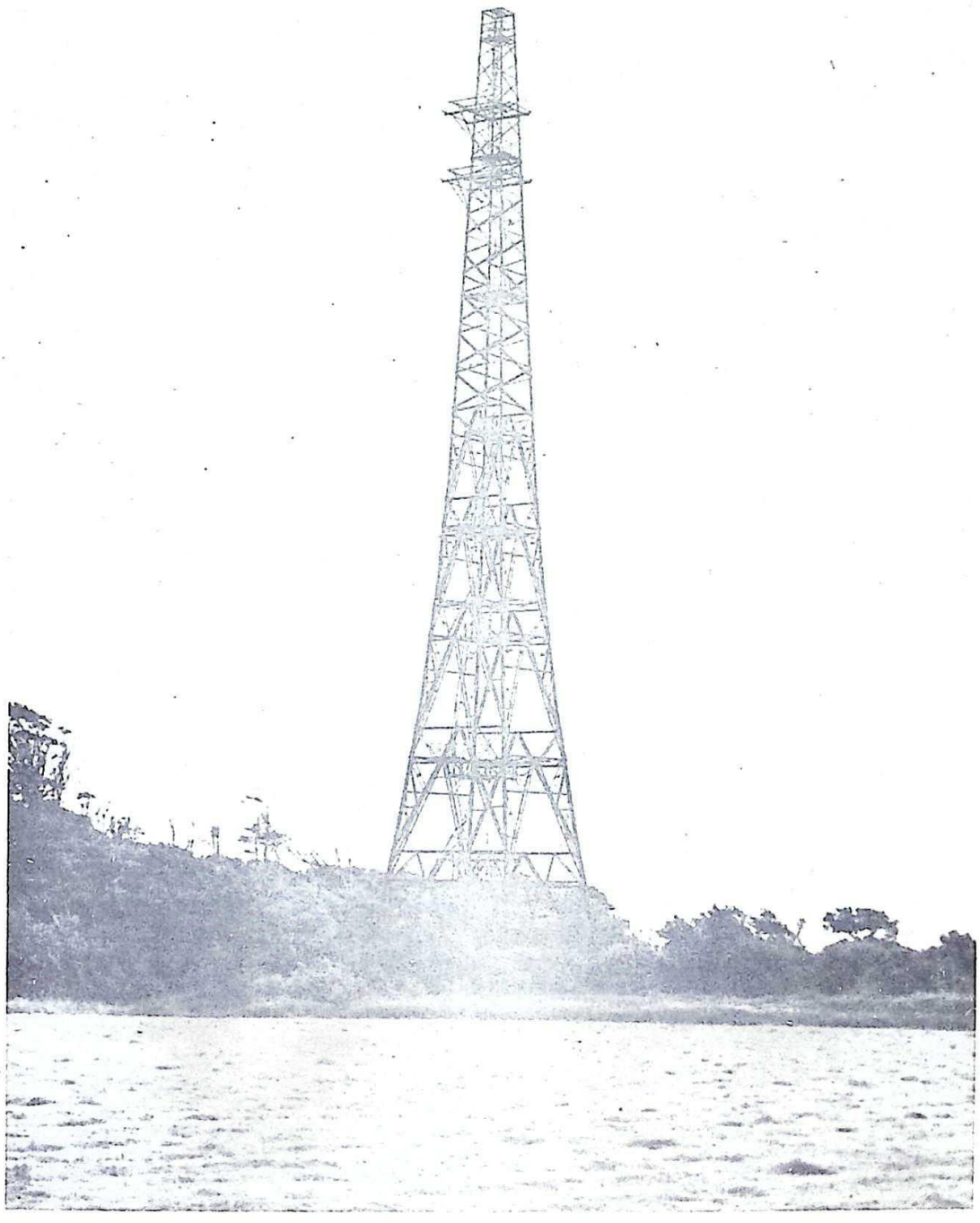
FIG. 4.

_____ Main array lobe pattern

– – – – Gap-filler lobe pattern

–·–·–·– Between these two parallel lines is the area of weak radiation on "main" and maximum radiation on "gap-filler".

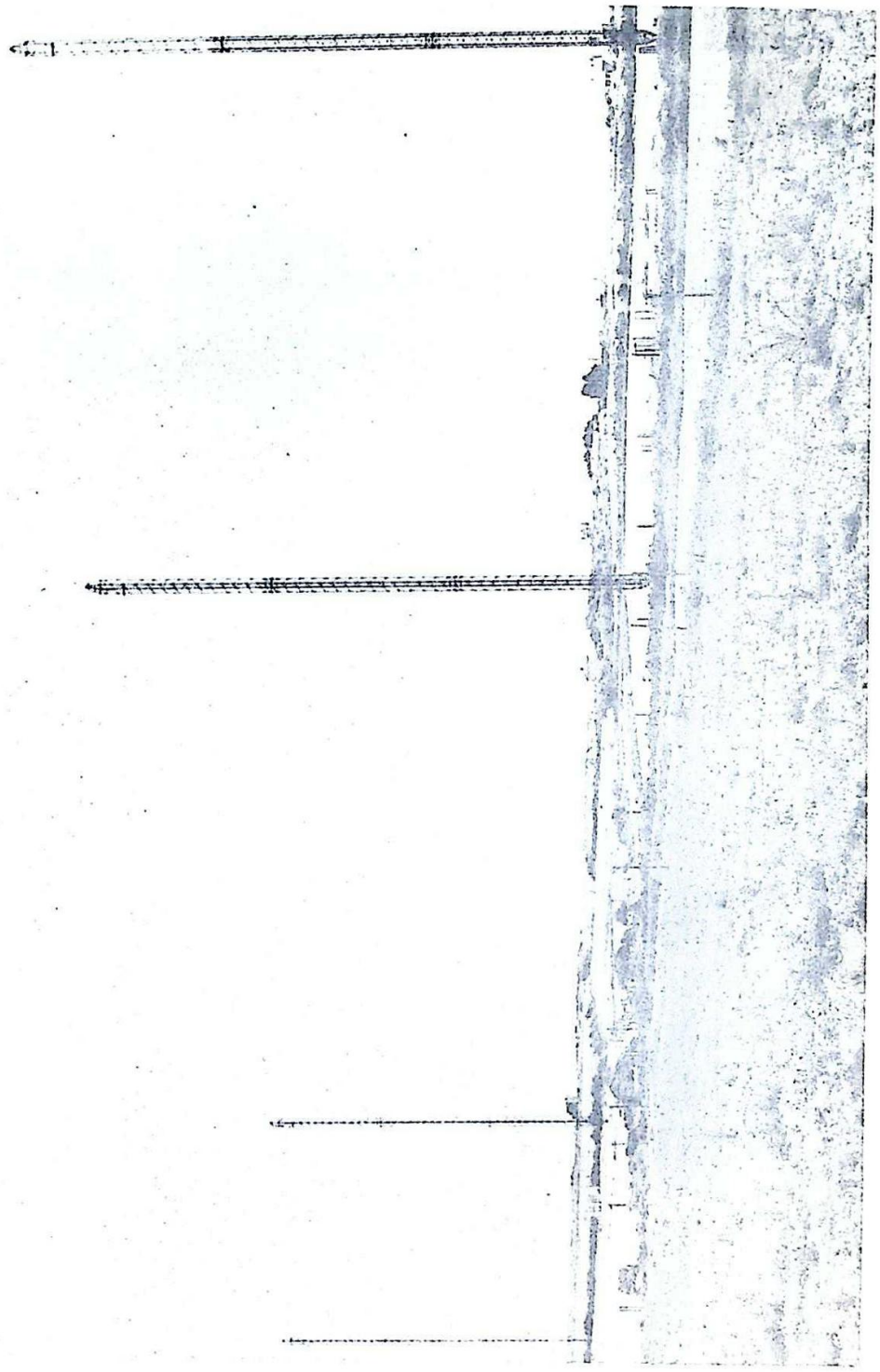
Fig. 2 : C.H. Receiver Aerials



Precis No. 11, Para. 5(c)

FIGHTER PLOTTERS PRECIS

Fig. 1 : C.H. Transmitting Aerials



Precis No. 11, Para. 5(c)

(d) Display. Cathode-ray tubes are used to display responses and their ranges. Two time bases are shown one above the other; one displays aircraft responses and the other I.F.F. responses (see Precis 12). Ranges are measured by use of an "electronic" range marker (Fig. 5).

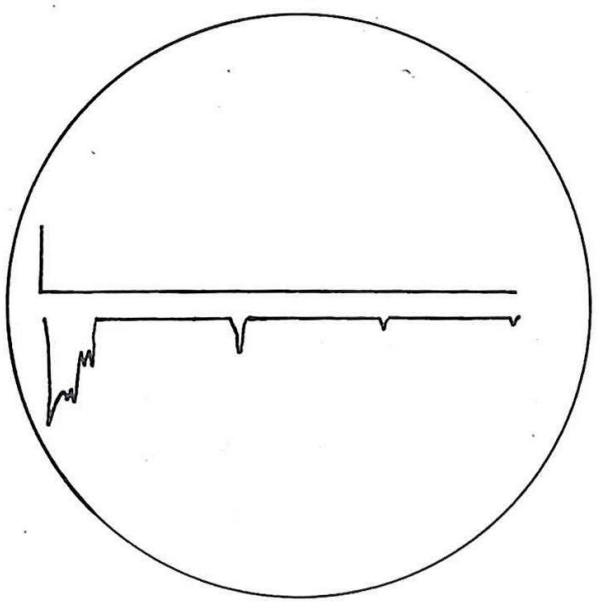
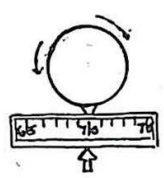


FIG. 5



(e) Information Produced.

(i) Ranges. With the use of the electronic range marker, ranges obtained are very accurate to distances of over 200 nautical miles.

(ii) Bearings. Bearings are determined by combining the signals received in two aerials set at right angles to one another and measuring the angle of the resultant. This resultant is difficult to measure so that bearings tend to be inaccurate.

(iii) Plan-Position. Because of bearing inaccuracies, plan-position on a single track may vary ("swing") considerably, especially at long-range when the response is poor. Plots from C.Hs. are therefore known as "non-directional". As ranges are accurate, however, accurate plan-position can be calculated by obtaining ranges on the same track from two or more C.Hs. and finding their intersecting point.

(iv) Strengths. The accuracy of strength assessment varies considerably. In a simple situation, where responses are clearly defined, assessments are often accurate. In a confused situation and particularly in the assessment of mass raids, on which many aircraft are observed at or about the same range, experience and considerable skill is required to assess strengths accurately.

(v) Heights. Heights are determined by comparing the signal received from two aerials at different heights. This gives the angle of elevation, which, related to the range of the aircraft enables the height to be determined. Height accuracy by these stations varies within considerable limits.

11.6. Radar Type 7 (G.C.I.)

(a) Function. Radar Type 7 is primarily used for control but use is also made of this source of medium and high cover (particularly overland) by the C.H.B. element of each G.C.I. station.

(b) Site. To ensure consistent, all round cover the G.C.I. site should be level for $\frac{1}{4}$ mile around the Type 7 array.

(c) Aerial. This is a common transmitting (Tx) and receiving (Rx) array. It comprises a number of dipoles arranged in stacks and bays. which beam the radiation in a series of vertically overlapping lobes with a horizontal beamwidth of approximately 12°. Complete cover in azimuth is attained by rotating the aerial through 360° (usually at 4 r.p.m.)(Fig. 6).

(d) Displays. Two types of display are used:-

(i) P.P.I. Displays. Control P.P.Is. are aligned for "magnetic" north (because the controller uses only magnetic bearings in messages to pilots). C.H.B. P.P.Is. are aligned for "true" north.

(ii) Height/Range Displays. For height finding purposes the Type 7 aerial can be divided into four height stacks with mean heights from the ground of $7\frac{1}{2}$ ft. - 10 ft. - $12\frac{1}{2}$ ft. and 25 ft. The height operator can, by operating a switch, select certain pairs of height stacks (e.g. $12\frac{1}{2}$ ft. and $7\frac{1}{2}$ ft.). Signals received by these stacks are compared and their ratio determined visually. Reference is then made to a height chart, a graph prepared for each Type 7 radar and the aircraft height is determined by relating the range of its response to the ratio measured.

(e) Information Produced.

(i) Plan Positions. Plan positions of detected aircraft can be accurately read directly from the P.P.I. display.

(ii) Strengths. The size of the 12° responses on the P.P.I. and the fact that the aerial may not be stopped to allow adequate study of the responses on the H/T display prevent reliable assessment of strength from Type 7 displays.

(iii) Heights. Position heights can be measured, accurate to within ±1,000 ft.

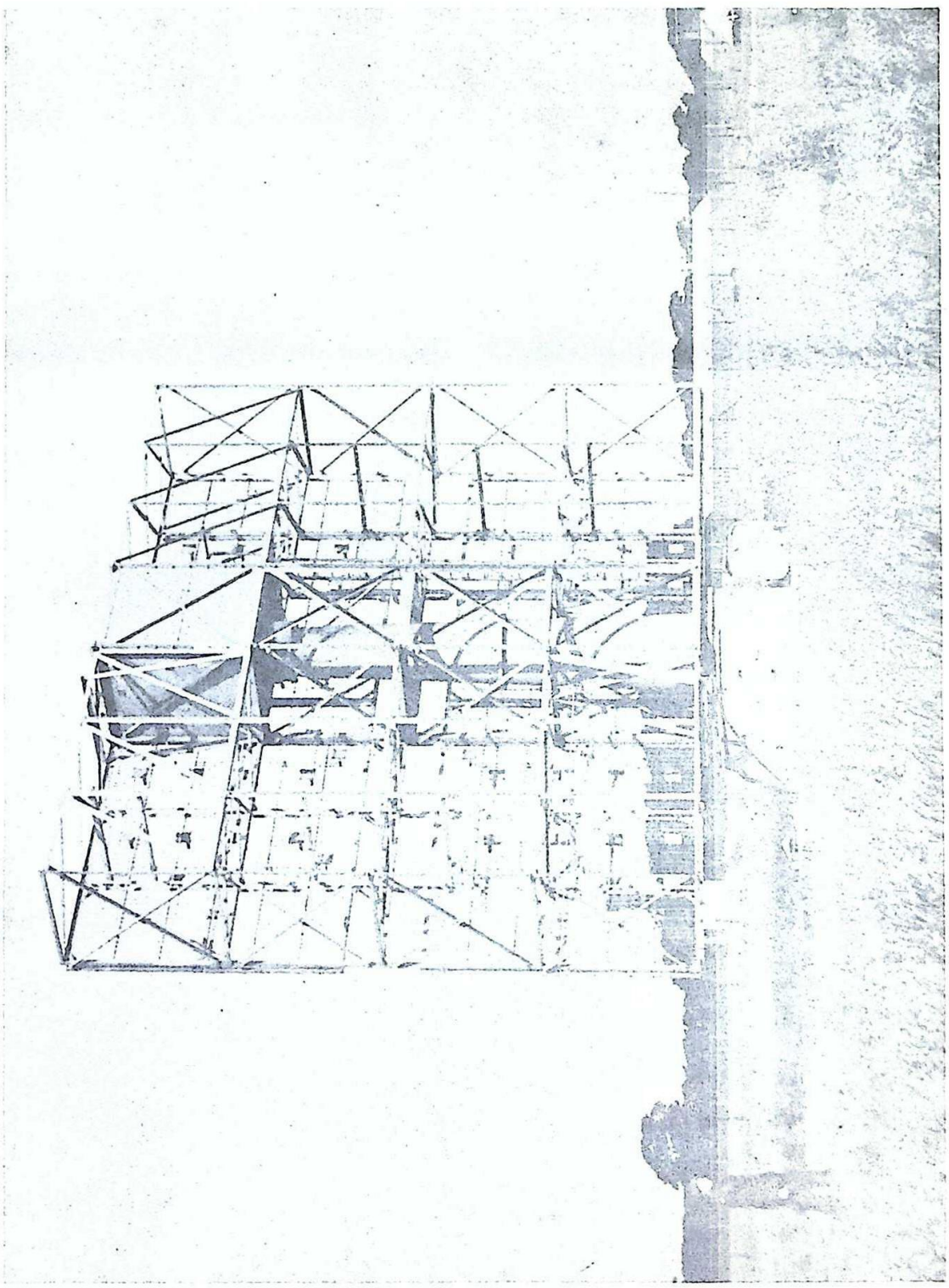
11.7. Radar Type 13 (Height Finder). This is a "centimetric" radar. It is invariably associated with one or more "search" radars.

(a) Function. To provide height information on selected responses detected by search radars.

(b) Site. Type 13 radar does not rely on level ground for height accuracy and can be sited on any open ground.

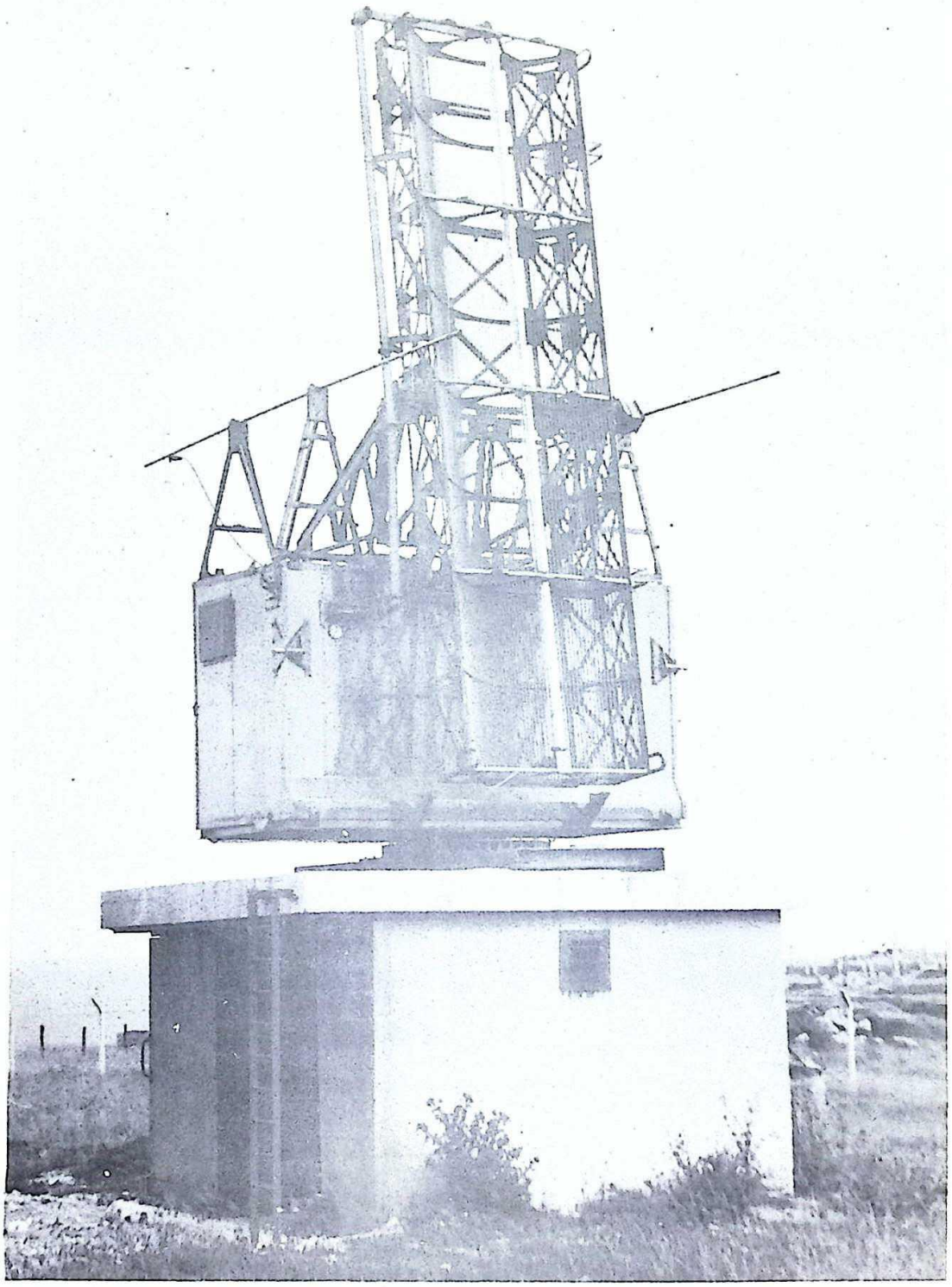
(c) Aerial.(Fig. 7). The common Tx and Rx aerial is mechanically rocked through angles of elevation from -1° to +20°.

Fig. 6 : Type 7 Aerial



Precis No. 11, Para. 6(c)

Fig. 7 : Type 13 Aerial



Precis No. 11, Para. 7(c)

Energy is transmitted from the aerial in a narrow beam (as a searchlight). The whole array can be turned in azimuth by remote control (see Para. 7(f)).

(d) Performance. Up to an angle of $\frac{3}{4}^{o}$ above the horizontal reliable heights cannot be obtainable. Above this angle accurate heights (± 500 ft.) are measured on aircraft flying at ranges up to 150 nautical miles.

(e) Display. An electrostatic tube known as a Range/Height Indicator (R.H.I.) is used to display height responses. The time-base pivots at zero range and is synchronized with the rocking of the aerial . The mask fitted over the tube is calibrated for range in 5 mile intervals and height in 5,000 ft. spacings.

(f) Method of Obtaining Heights.

(i) A search radar P.P.I. is used in conjunction with Type 13 radar.

(ii) A "cursor bar" over the P.P.I. display is aligned with the direction of propagation of the Type 13 aerial.

(iii) The aerial is turned by remote control and the cursor bar automatically follows.

(iv) When the P.P.I. operator has brought the hair line of the cursor over a selected response the aerial is pointing on the required direction in azimuth. As the rocking beam scans vertically, the response is "painted" on the R.H.I. as a short vertical line, the centre of which indicates the height of the aircraft.

(g) Information Produced.

(i) Heights. Positive heights can be determined within ± 500 ft. Greater accuracy can be obtained by comparative heights at the closing stages of an interception.

(ii) Strengths. The Type 13 is a useful auxiliary source of raid strength information.

(iii) Plots. By converting measurements of range and bearing, plots can be obtained from the Type 13 radar. A raid can be detected and followed by "inching" (remaining on target by minute movements of the remote turning gear). Bearings are indicated by the cursor bar (and on the turning gear control) and ranges by the R.H.I. display. This plotting source is useful when metric radars are jammed and when raids are above the average of centimetric search radar.

(iv) Meteorological Information. Useful information is given to the meteorological authorities on cloud formations detected by this radar.

11.8. Type 14 (Centimetric Search) Equipment.

(a) Function. Primarily used as a control radar, use is also made of this source of cover (particularly overland) by the C.H.B. elements of each G.C.I. station.

(b) Site. Type 14 cover does not depend on a level reflecting surface and the radar can be sited on any open ground.

(c) Aerial. The common Tx and Rx aerial (it is similar to Type 13, but its main axis is in the horizontal plane) can be fixed at an angle in the vertical plane to suit operational requirements. Complete azimuthal cover is provided by rotating the aerial through 360° (usually at 4 r.p.m.)(Fig. 8).

(d) Performance. Gapless cover can be afforded by having more than one Type 14 at varying angles of tilt. Plan-position of aircraft to considerable ranges can be read off the display with a high degree of accuracy. Performance is affected by heavy rainclouds, which reflect the radiation and may obscure large areas of the display.

(e) Display. As for Type 7, P.P.I. displays are employed but responses "paint" as spots, making it easier to discriminate between positions of individual raids.

(f) Information Produced.

(i) Plan-positions. The responses are painted as fine spots of light thus affording extremely accurate determination of plan-position.

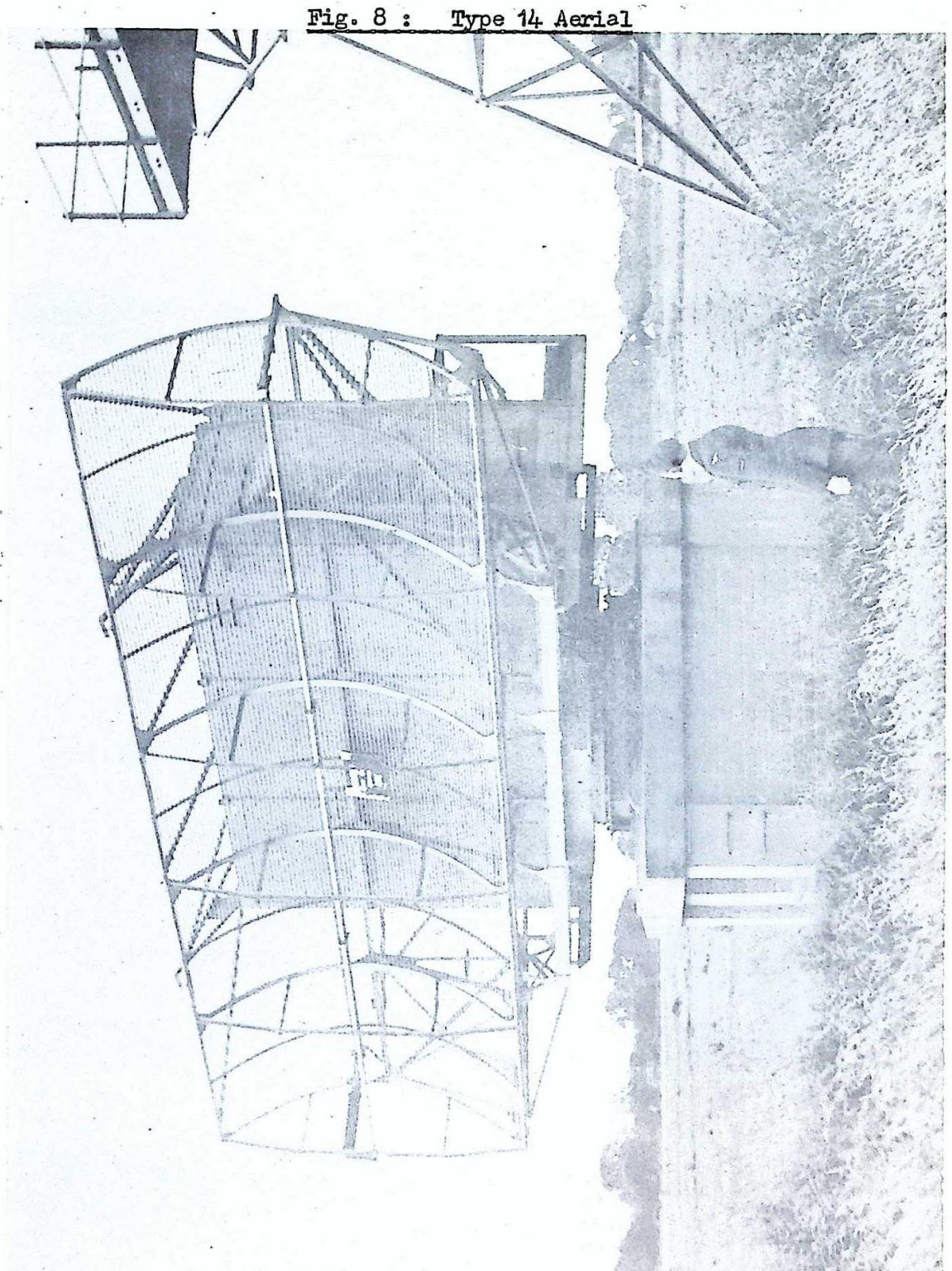
(ii) Strengths. Fine pin-point responses make for greater accuracy in the assessment of raid strength than Type 7 radar.

(iii) Meteorological Information. This radar is also used in connection with reports of cloud formations passed to the Meteorological authorities.

11.9. Radar Type 54 - Chain Home Extra Low (C.H.E.L.)

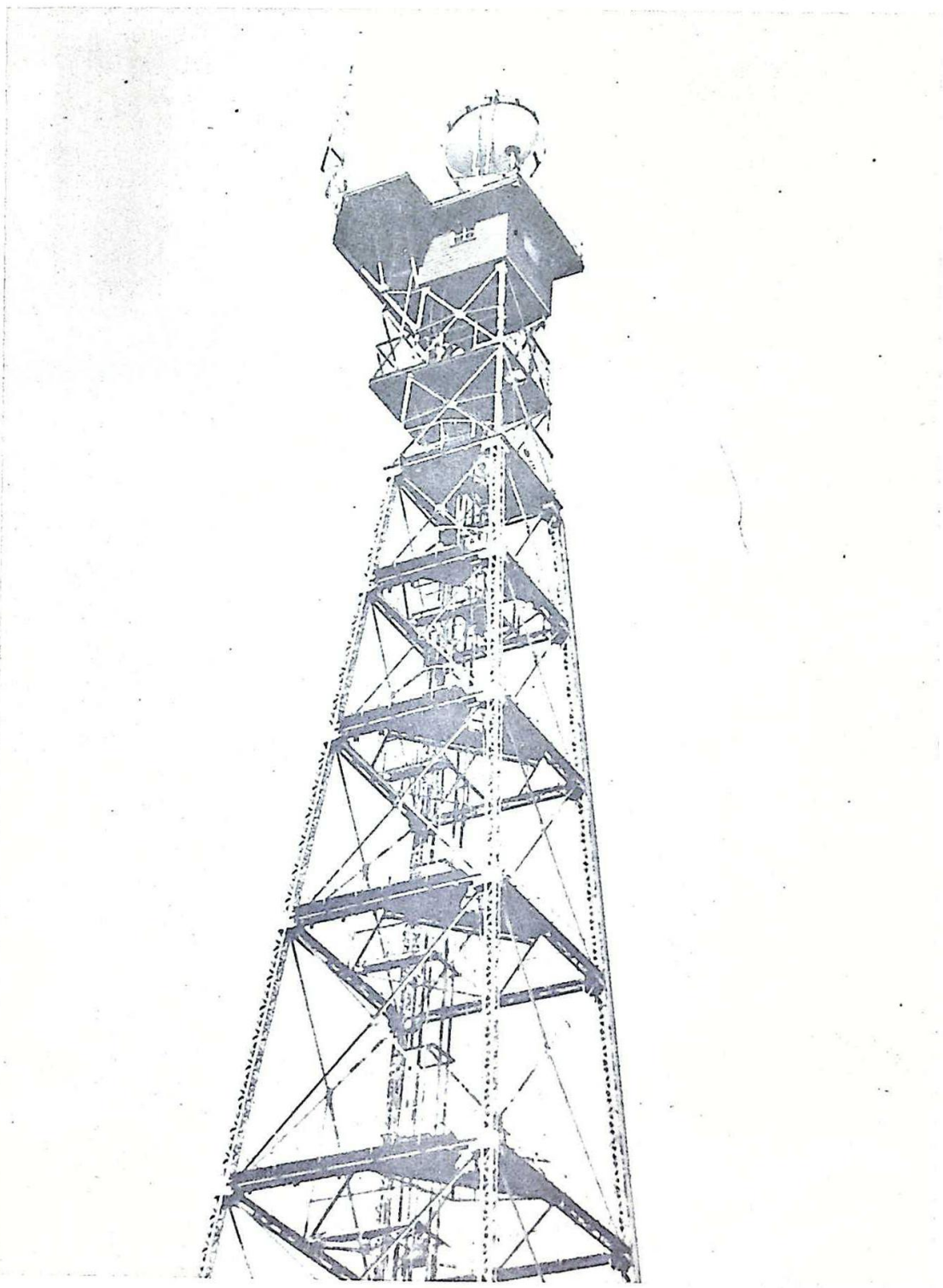
(a) Function. This centimetric radar is used to detect raids approaching the U.K. coasts at very low level. It also serves as a source for reporting the movement of shipping around the coast.

Fig. 8 : Type 14 Aerial



Precis No. 11, Para. 8(c)

Fig. 9 : Type 54 Aerial



Precis No. 11, Para. 9(c)

(b) Site. To obtain maximum low cover Type 54 radar is sited on the highest available ground on, or very near to, the coast.

(c) Aerial. The aerial is mounted on a 200 ft. tower. It is a commom Tx and Rx aerial consisting of a reflector shaped like a saucer. Energy is directed into the reflector, whence it is reflected in a narrow beam. The beam normally rotates continuously at 4 r.p.m. (Fig. 9).

(d) Performance. High coastal sites afford a large area of surface cover and low cover out to considerably ranges (approximately 100 nautical miles provided the aircraft is above the optical horizon. Performance deteriorates:-

(i) Within surface cover when heavy seas cause "wave clutter" (reflections from high waves) to obscure the display.

(ii) During periods when heavy rain clouds obscure large areas of the P.P.I. display.

(e) Displays. P.P.Is. are employed and responses print as spots.

(f) Information Produced.

(i) Plan-position. Plan-positions of low-flying aircraft and surface vessels can be detected with a high degree of accuracy. This type of radar provides early warning on "rat" raids.

(ii) Strengths. The fine pin-point responses make for accuracy of assessment of strengths of both aircraft and shipping.

(iii) Meteorological Information. As in the case of the Type 14, reports on cloud formation detected by this radar, are passed to the meteorological authorities.

SECTION IV : RADAR

PRECIS 12 : IDENTIFICATION FRIEND OR FOE

INTRODUCTION

12.1. In order to distinguish between friendly and enemy aircraft, special radar equipment was fitted to friendly aircraft to enable them to identify themselves, to allied ground radar stations. This equipment is known as I.F.F. and the frequencies it employs is the "A" band. It is not employed in peace-time.

12.2. In order additionally to distinguish between friendly fighters and all other aircraft for the nenefit of controllers, a further development of I.F.F. equipment, employing an additional frequency band - the "G" band - is fitted to all friendly fighters.

12.3. The "A" band may be said to have a reporting use, the "G" band a control use. It should be noted that equipment which include the "G" band, operate also, by a time sharing process, on the "A" band.

REPORTING USE

12.4. The most recent version of I.F.F. equipment operating only on the "A" band was known as I.F.F. Mk 3 A. It enabled reporting stations to pass to C.C.F.Ps. evidence of the friendly identity of aircraft echoes showing its distinctive associated response.

CONTROL USE

12.5. During periods of intense flying activity it is often difficult for an interception controller to distinguish the response of the fighter assigned to his control amongst the many responses on the P.P.I. display. I.F.F. Mk 3G.R. is fitted to nearly all fighter aircraft to assist the controller in this task.

12.6. I.F.F. Mk 3 G.R. The operation of the equipment is as follows:-

(a) The transponders in the aircraft are switched rapidly and automatically between "A" band and "G" band. The transmitter on "G" band is inoperative except by the pilot on instructions from the controller.

(b) The "transponder" operates on the same frequency as G.C.I. Type 7 radar.

(c) The airborne I.F.F. receiver detects pulses from the G.C.I. Type 7 radar. These pulses cause the transmitter when operated, to function, and send pulses back to the ground radar.

(d) I.F.F. pulses are therefore only transmitted whilst the detecting radar beam scans the fighter. The response on the P.P.I. display assumes a distinctive pattern (Fig. 1). This I.F.F. is known by the R/T code word "CANARY".

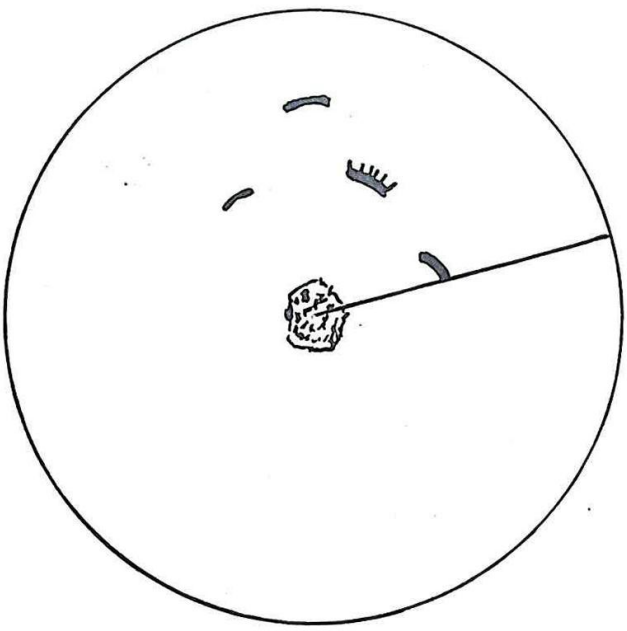


FIG. 1.

12.7. Operation of I.F.F. Mk 3A.

(a) Separate I.F.F. transmitter and receiver units were fitted at all R.R.Us.

(b) In wartime all allied aircraft were fitted with I.F.F. transmitter and receivers (transponders).

(c) Transponders were switched "on" whenever aircraft were over, or approaching defended territory.

(d) Ground I.F.F. transmitters sent out pulses. Transponders in allied aircraft within I.F.F. cover sent back an "answering" pulse to ground I.F.F. receivers.

(e) Returned I.F.F. pulses from an aircraft were displayed on the range tubes at R.R.Us. at the same time/range as the radar responses were received from that aircraft.

(f) A separate trace was used to display I.F.F. responses. This trace was calibrated and synchronized with the radar trace. Radar and I.F.F. responses were thus rapidly associated.

EMERGENCY FACILITIES

12.8. Distress. In cases of emergency a pilot may switch his Mk 3A or Mk 3 G.R. transponder to transmit "Distress" pulses. These pulses are displayed as broad responses (Fig. 1) and the associated track is accorded priority of telling.

SECTION V : V.H.F. RADIO IN THE C. & R. SYSTEM

PRECIS 13 : V.H.F. R/T

Introduction

13.1. The control of fighter formations depends fundamentally on satisfactory communication between ground control stations and airborne fighters. For both air/air (pilot to pilot) and air/ground (pilot to controller) communications Fighter Command employs V.H.F. (very high frequency) R/T (radio-telephony) equipment.

R/T "Channels"

13.2. "Channel" is the term used to describe a specific frequency allocated for R/T communication.

(a) Fighter aircraft are fitted with 20 channel V.H.F. R/T equipment. Channels are either numbered (at ground stations) or lettered (in aircraft) for quick reference and each channel has a specific function (see para. 3). The pilot can select any required channel by means of a simple, quick, push-button system.

(b) Ground control stations (i.e. Air Traffic Control, G.C.Is. etc.) are provided with a number of R/T channels, dependent on operational requirements. These channels (transmitters and receivers) are housed in V.H.F. stations, usually sited a short distance (one to three miles) from the control station and are operated by "push-button" remote control.

Allocation of Channels

13.3. Allocation to Fighter Aircraft. A typical allocation of the 20 Channels in a contemporary fighter aircraft might be:-

(a) Seven for Air Traffic Control and Safety Services

(b) Five for fixer facilities (parent sector and adjacent sectors).

(c) Four for G.C.I. control within the sector

(d) One for use when a fighter wing operates as a fighter formation.

(e) Three for reinforcement ("Refors"). These channels, common to all sectors, are used when fighters from adjacent sectors reinforce the fighters of a hard pressed sector.

13.4. Allocation to Ground Control Stations. A typical allocation of channels to a G.C.I. station is as follows:-

(a) Three channels for G.C.I. control sectors of the fighters

(b) One "sector fixer" channel

(c) Three channels for use when the fighter wings within the sector operate as single formations.

(d) Three "reinforcement" (Refors) channels, used to control fighters from adjacent sectors when the sector is hard pressed.

NOTE: If it is desired to change a frequency, ground stations can (if crystals for the new frequency are available) do so in a very few minutes.

V.H.F. R/T Coverage

13.5. The distance at which satisfactory ground/air communication by V.H.F. R/T can be maintained depends on:-

(a) The radio equipment (i.e. the power of the transmitting system and the sensitivity/selectivity of the receiving system).

(b) V.H.F. station site and aircraft height. V.H.F. radio waves proceed on straight lines and cannot be received from below the optical horizon therefore:-

(i) The higher the V.H.F. aerials, the further cover is extended for a given aircraft height.

(ii) The higher the aircraft flies the further cover is extended from a given V.H.F. station site.

13.6. Range of V.H.F. R/T. V.H.F. range increases with the altitude of the aircraft and can be estimated accurately enough for all practical purposes by the following formula:-

Range (miles) = $1.25(\ h^t + h^r\ )$

where h^t = ht. in feet of transmitting aerial

and h^r = ht. in feet of receiving aerial

i.e. Thus for a transmitter aerial ht. of 50 ft. the V.H.F. range of an aircraft at 1,500 ft. is about 55 miles, at 5,000 ft. about 95 miles, at 10,000 ft. about 130 miles and so on.

13.7. Increasing the Range. Where it is operationally expedient and geography permits "forward relay V.H.F. stations" are used to increase the effective range of ground/air V.H.F. R/T communications. When a controller notes that R/T communication with his fighters is becoming faint with increasing range, he is able, by remote control over land-lines, to switch in a "forward relay" which operates a duplicate channel at a V.H.F. station some 10s of miles nearer to his fighters. Thus he increases R/T range by the distance from the control station to the "forward relay" station.

Limitations in Fighter Command's use of V.H.F. R/T

13.8. Fighter Command is limited in its use of V.H.F. R/T by :-

(a) The small number of V.H.F. frequencies available (approximately 100)

(b) The number of uses to which these "few" frequencies must be put, viz:-

(i) Air to Air

(ii) G.C.I. Control

(iii) Air Traffic Control

(iv) Distress (including search and rescue)

(v) Navigational aids (D/F fixing etc.)

(c) The difficulties which arise when more than one formation is controlled on one frequency (e.g. the unintentional jamming of one ground station by another, the ground stations being inaudible to each other but not to the aircraft concerned).

(d) The fact that usually seven of the frequencies available to each fighter pilot are allotted for Air Traffic Control and safety services, leaving only 13 for G.C.I. (and naval - see note) control.

NOTE: Fighters may be required to operate under naval control when defending coastal convoys.

SECTION V : V.H.F. RADIO IN THE C. & R. SYSTEM

PRECIS 14 : THE FIGHTER COMMAND V.H.F. FIXER ORGANIZATION

PURPOSE

14.1. V.H.F. Fixer Systems in General

(a) A V.H.F. fixer system is a means whereby the position of an airborne aircraft can be determined by ground stations, with varying degrees of accuracy, from V.H.F. transmissions made by the aircraft.

(b) To be effective the technique requires the co-operation of the aircraft's crew.

14.2. The Fighter Command Organization. The Fighter Command V.H.F. fixer organization is maintained for the following reasons:-

(a) To assist interception controllers and fighter marshals by providing a means, alternative to radar, of determining (with varying degrees of accuracy) the positions of fighter aircraft when airborne.

(b) To assist interception controllers and fighter marshals by providing a means, alternative to the use of "canary", of determining which response of (perhaps) many on a radar display is produced by the aircraft under control. The controller relates the "fixed" position to that of a particular response.

(c) To serve as a navigational aid for fighter pilots.

COMPOSITION

14.3. Each Fighter Sector operates one or more V.H.F. fixer systems, the number being sufficient both:-

(a) to provide complete cover at heights above 2,000 feet over the entire Sector and to seaward as far as is practicable; and

(b) to handle the anticipated activity.

14.4. A typical system comprises:-

(a) D/F Stations. From three to six in number, perhaps 40 miles apart being grouped in a cluster, not disposed in a line. A D/F station is capable of determining (with varying accuracy) the azimuthal bearing from which it receives a radio transmission.

(b) A Triangulation Centre. When an aircraft's transmission is heard, of sufficient strength and duration for bearing-determination, the D/F stations pass their bearings to the system's triangulation centre. Here the bearings can be plotted on a chart-table so as to disclose, by their common intersection, the position of the aircraft (the purpose being known as "triangulation").

14.5. All the D/F stations in any one fixer system use a common frequency, but no two systems (normally) use the same. The frequency is allocated to a sector fighter marshal and all communication between air and ground in connection with fixing is handled by him.

14.6. The triangulation centres for each of a Sector's systems are (usually) all located within a single room in the S.O.C.

THE V.H.F. D/F STATION

14.7. Equipment.

(a) Consists essentially of a V.H.F. receiver fed from a horizontally rotatable, highly directional, aerial array.

(b) The aerial is hand-rotated, its orientation being indicated to the operator by a calibrated dial incorporated in the turning mechanism.

(c) The aerial array comprises two vertical dipoles backed by two similar dipoles which act as reflectors (see Fig. 1).

(d) If the aerial is rotated while a transmission is being received, the signal heard by the operator will steadily vary in intensity. Whenever the plane of the receiver-dipoles points towards the transmitting aircraft (i.e. twice in every 360° rotation), the signal will be heard the most strongly (a "maximum"); whenever it is perpendicular to that direction, the signal will be heard the most weakly (a "minimum"). Through the intervening positions signal strength will steadily increase or decrease, as the case may be.

(e) By means of a "sense plate" attached to the aerial turning wheel, the operator can readily "switch-out" (i.e. render inoperative) the two reflector-dipoles. The reason for incorporating this feature will become apparent in the following paragraph.

(f) Two receivers are normally installed at each D/F station and the aerial can be instantly switched from one to the other. This permits the station to change to a second frequency with great rapidity.

14.8. Operation

(a) The station can be operated by a single person. Normally, however, there are two operators on each watch.

(b) To determine the bearing of a transmitting aircraft, the operator rotates his aerial until he receives a minimum signal. (The ear can determine a minimum more precisely than it can a maximum). The plane of the receiver-dipoles must now be perpendicular to the direction of the aircraft (para. 7(d)).

(c) The turning-gear dial (para. 7(b)) is calibrated, however, to indicate not the actual "lie" of the receiver-dipole, but a direction at right angles - i.e. either the bearing of the aircraft or its reciprocal.

(d) To determine which, the operator turns the aerial just sufficiently off the minimum to secure an audible signal; switches-out the reflectors by lifting the sense plate (para. 7(e)); and notes whether the signal is thereby decreased or increased. If decreased, the bearing indicated was the required one; if increased, it was the reciprocal.

(e) The operator is required to pass to the triangulation centre the true (not magnetic) bearing of the aircraft.

14.9. Classification of D/F bearings. The precision with which the D/F operator can determine a minimum signal depends on many factors - notably on the position and height of the aircraft transmitting. Bearings are therefore classified, the classifications being:-

1st class bearing: one which the D/F operator may reasonably consider to be accurate within ± 2°.

2nd class bearings: one which the D/F operator may reasonably consider to be accurate only within ± 5°.

3rd class bearings: one which the D/F operator may reasonably consider to be accurate only within ± 10°.

If the operator does not consider his bearing to be accurate within ± 10°, he passes "no bearing".

THE TRIANGULATION CENTRE

14.10. The Triangulation Table

(a) The table on which the bearings are plotted carries a horizontal map of the area served by the system.

(b) From a hole at the location of each D/F station, as shown on the map, emerges a ring which is attached to a weight cord passing through the table.

(c) Around each hole is displayed a compass-rose indicating true bearings.

14.11. Display of Bearings

(a) Triangulation plotters are disposed around the table, one for each of the contributing D/F stations.

(b) Each plotter is in continuous, direct, telephonic communication with his associated D/F operator.

(c) The D/F operator, on determining a bearing, passes (i) the aircraft callsign (ii) the classification of the bearing and (iii) the bearing, to the plotter.

(d) If the bearing is first class, the plotter displays it, using the ringed cord in conjunction with the appropriate compass-rose, and repeats aloud the aircraft call-sign.

(e) If the bearing is second or third class, the plotter will await the triangulation teller's (see para. 16(c)) demand before displaying it and announcing the aircraft call-sign.

14.12. The Triangulation Teller

(a) Because the bearings are generally - to the extent indicated in para. 9 - inaccurate, it is most unlikely that they will intersect in a common point. Normally, their several intersections are spread over a small area.

(b) A decision has, therefore, to be made: which point in this area is to be taken as the position of the aircraft?

(c) An experienced fighter plotter, known as the triangulation teller, is invested with the responsibility for:-

(i) choosing the position (see para. 16)

(ii) classifying its accuracy (see para. 17)

(iii) passing position and classification to the user (see para. 23)

(iv) supervising triangulation generally.

14.13. The Triangulation Recorder. The triangulation recorder maintains a record of each fix passed by the triangulation teller, noting:-

(a) call-sign of the aircraft concerned

(b) grid-reference of the "fixed" position

(c) class of fix

(d) time at which the fix is passed to the user.

TRIANGULATION

14.14. Basic Principle. Given a number of bearings (generally of various classes), all appertaining to the same aircraft and taken simultaneously, the process of fixing the aircraft from first principles would clearly be:-

(a) To visualize the 2° (first class), 5° (second class) or 10° (third class) limits either side of each bearing, as appropriate to its class. That is, to see "bearing-zones" rather than bearing-lines.

(b) To visualize the single, small, area common to all bearing-zones (see Fig. 2).

(c) The centre of this area would then be the position best chosen as the fix.

(d) The distance of the corner of the area furthest from the chosen position would represent the probable maximum error in fixing.

14.15. Practice. Speed is all-important in fixing. If a minute is allowed to elapse between bearing-measurement at the D/F stations and the receipt of the resultant fix by the user, the aircraft may well have travelled 10 miles or more in the meantime. It is therefore necessary for the whole triangulation process to be conducted without the slightest hesitancy and with some simplification of the procedure set forth in para. 14.

14.16. Triangulation Teller: Sequence of Actions. In fixing an aircraft, the triangulation teller must pursue the following sequence:-

(a) Ensure that all bearings appertain to the same aircraft.

(b) The triangulation plotter, in the first instance, displays only first class bearings (para. 11). If there are at least three significant bearings among them, accept the centre of the area they enclose as the fix.

(c) If not, call for "seconds" (second-class bearings). If there is now a total of at least three significant bearings,* select the fix in accordance with para. 11.

NOTE: * Significant bearings:-

(a) Where two bearings are within 20° of parallelism, they are only to be counted as one, significant, bearing.

(b) Bearings wrongly determined or wrongly plotted have, of course, no significance. The triangulation teller must be alert to detect manifest errors. D/F operators occasionally (although

without justification) confuse bearing and reciprocal and, unwittingly, pass the latter. Again misunderstanding may occur between D/F operator and plotter (e.g. a bearing of 251° may be displayed as 291°).

(d) If there are still fewer than three significant bearings, call for "thirds" (third class bearings). Select the fix in accordance with para. 14.

(e) Classify the fix according to the standards of para. 17.

(f) Pass the fix and its classification to the users (see para. 23).

14.17. Classification of Fixes. Fixes are classified by the following standards:-

A Class. One which the teller may reasonably consider to be accurate within 5 nautical miles.

B Class. One which the teller may reasonably consider to be accurate only within 20 nautical miles.

C Class. One which the teller may reasonably consider to be accurate only within 50 nautical miles.

14.18. Classifying the Fix. While fixes will, in principle, be classified in accordance with paras. 14 (d) and 17, the triangulation teller may safely consider any fix as Class A if it is derived from three significant bearings of which at least two are first class.

PROCEDURE BY WHICH A FIX IS CALLED FOR

14.19. Fix Required by Sector Fighter Marshal. The Sector Fighter Marshal normally controls exclusively on his fixer frequency so that, when he requires a position from the triangulation teller, he has only to instruct the formation leader to make a transmission of suitable length (see para. 22).

14.20. Fix Required by an Interception Controller

(a) Interception controllers rarely, if ever, control on a sector fixer frequency.

(b) The Controller therefore orders the pilot to "go over" to the appropriate fixer frequency, to "transmit for fix", and forthwith to return to the control frequency.

(c) No warning need be given by the interception controller before utilizing a fixer system in this way. The D/F stations have only to hear the aircraft transmit specifically for a fix to take action. Indeed, fixer systems fix any transmission of suitable length, whether or not fixing is asked for, if the aircraft callsign is given.

14.21. Fix Required by a Pilot. A fighter pilot, requiring a fix for his own assistance, may call the appropriate sector fighter marshal requesting that a fix be taken and passed to him (the pilot) by R/T.

ACTION TAKEN BY A PILOT WHEN TRANSMITTING FOR A FIX

14.22. When a fix is required, the pilot transmits (on the appropriate Sector Fixer Frequency) for at least 10 seconds, prefixing his transmission with the callsign of the sector fighter marshal followed by his own. The 10-second transmission in war-time usually consists

of carrier-wave alone (that is, the pilot continues to depress his transmitter switch without speaking), or of a repetition of the pilot's callsign. In peacetime it is more commonly occupied by the pilot passing his course, height and airspeed. The 10-second period is the shortest time in which a D/F operator can locate a minimum signal and "sense" it.

PASSAGE OF FIXES FROM THE TRIANGULATION TELLER TO USER

14.23. The triangulation teller passes fixes to users over a landline-broadcast system. He is equipped with a head-and-breast set to this end.

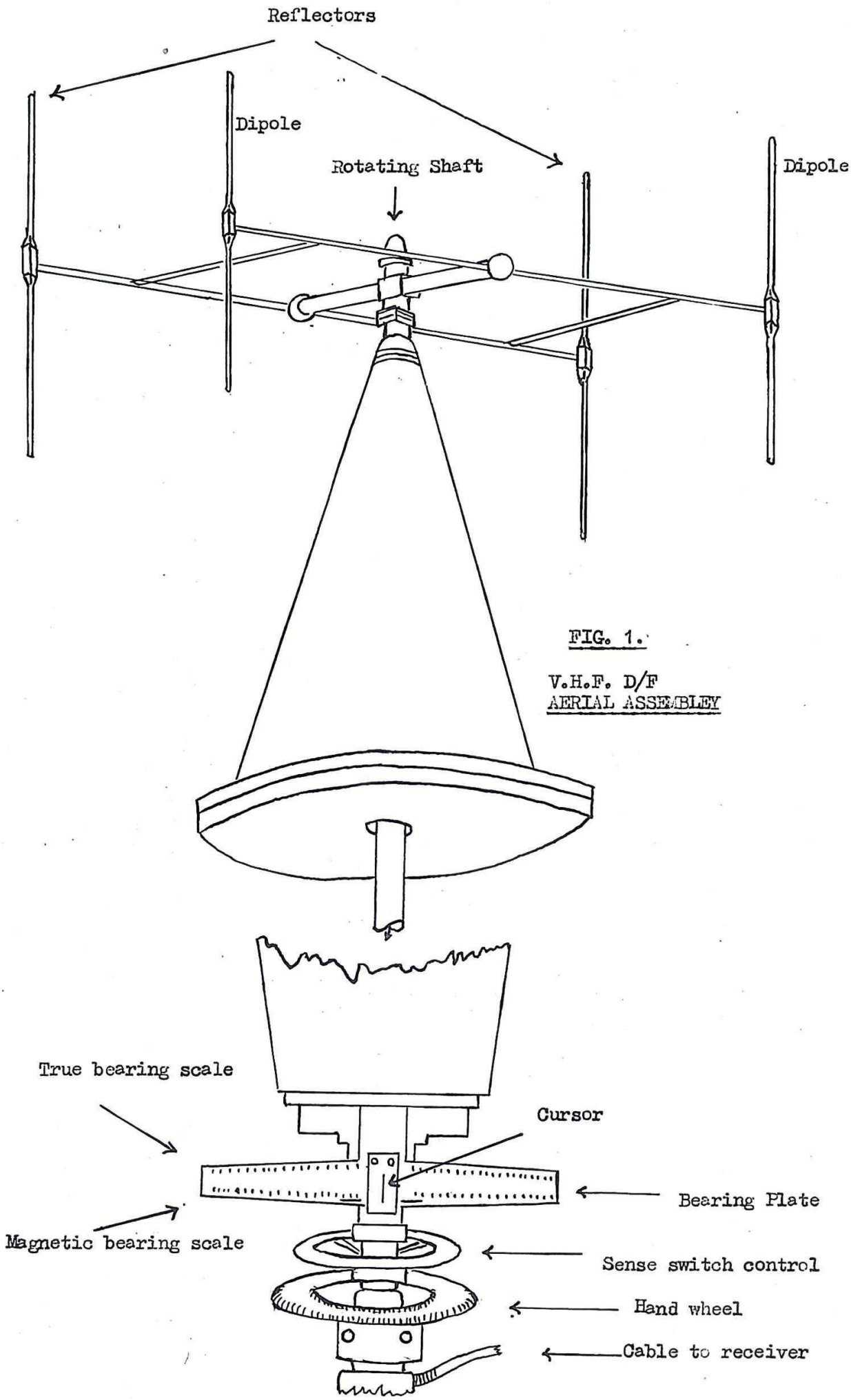
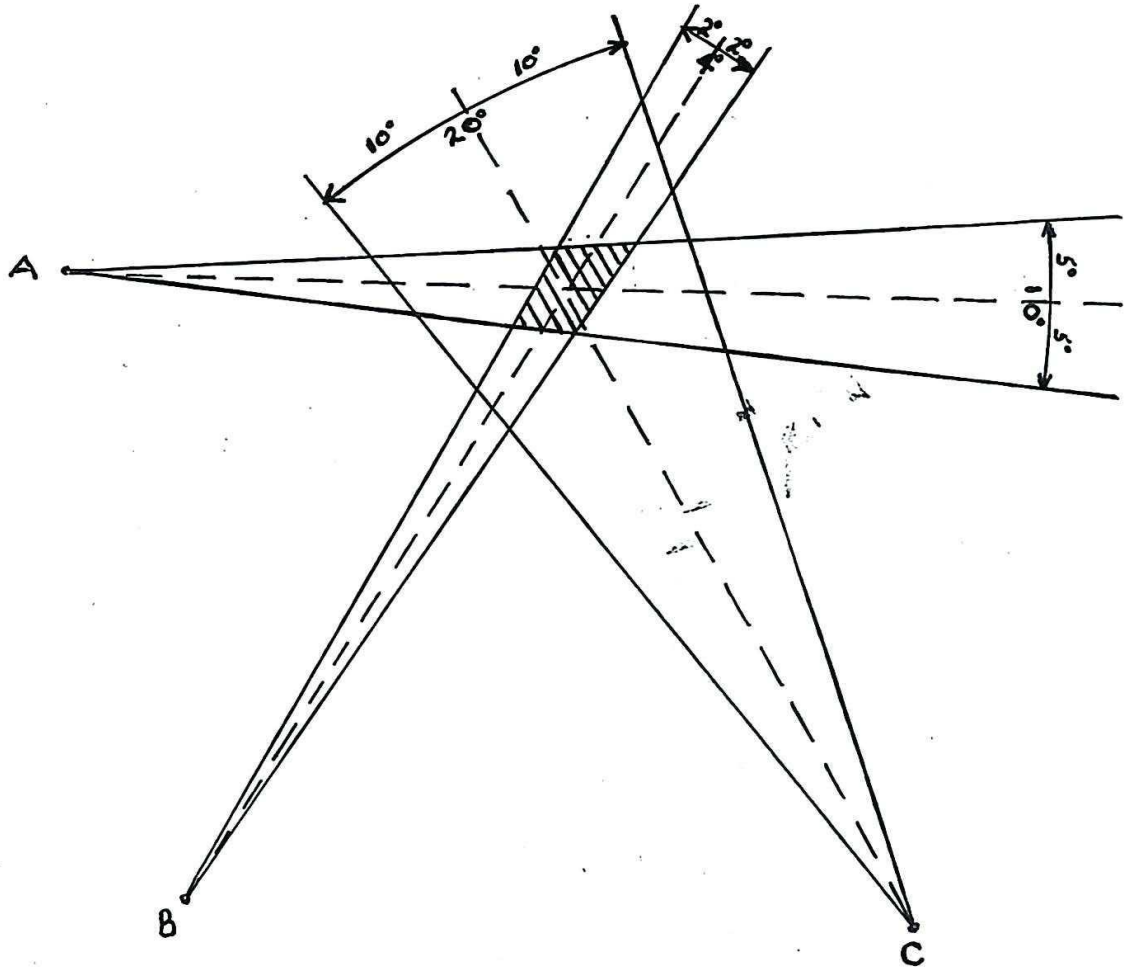


FIG. 1.

V.H.F. D/F
AERIAL ASSEMBLEY



PRECIS No. 14. PARA 14(b)

FIG. 2

D/F TRIANGULATION

SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 15 : PHONETIC SPEECH

INTRODUCTION

15.1. Clear pronunciation is of major importance in the passage of messages over communication networks within the C. & R. system. Messages are often misunderstood because of either:-

(a) Poor reception over faulty landlines, or,

(b) The dialect of the speaker.

15.2. Clarity of messages (e.g. plots, heights, ranges etc.) is ensured by using:-

(a) A phonetic alphabet

(b) Clear pronunciation of numerals.

THE PHONETIC ALPHABET

15.3. The following examples indicate the confusion which might arise:-

(a) A might be misheard as J

(b) B might be misheard as P.

but, using a short word to clarify each letter, the possibility of confusion is eliminated, thus:-

A is told as ABLE

B is told as BAKER

The full phonetic alphabet used in the C. & R. system is:-

A	ABLE	N	NAN
B	BAKER	O	OBOE
C	CHARLIE	P	PETER
D	DOG	Q	QUEEN
E	EASY	R	ROGER
F	FOX	S	SUGAR
G	GEORGE	T	TARE
H	HOW	U	UNCLE
I	ITEM	V	VICTOR
J	JIG	W	WILLIAM
K	KING	X	X-RAY
L	LOVE	Y	YOKE
M	MIKE	Z	ZEBRA

The success of this system depends on the precise use of the correct phonetic alphabet.

15.4. Use of the Phonetic Alphabet

(a) "Georef Plots". The letters indicating the primary and/or secondary areas are always told using the phonetic alphabet (e.g. MKPG is told as MIKE KING PETER GEORGE).

(b) Clarifying Verbal Messages. The phonetic alphabet can be used to spell out the important parts of messages (e.g. names, places etc.) when reception over landlines is poor.

Numerical Pronunciation

15.5. The following examples indicate the confusion which might arise when telling numbers:-

(a) Five might be misheard as nine.

(b) Seven might be misheard as eleven.

(c) Fifty might be misheard as sixty.

15.6. To avoid the possibility of confusion single numbers are pronounced as follows:-

1	2	3	4	5	6
WUN	TWO	THREE	FOWER	FIFE	SIX
7	8	9	0		
SEVEN	EIGHT	NINER	ZERO		

When clarity is in doubt, numbers should always be told singly. In example 5(b), eleven told as WUN WUN and in 5(c) fifty as FIFE ZERO, would eliminate confusion.

15.7. Time is vital in the C. & R. system. The correct and clear pronunciation of messages saves valuable seconds.

SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 16 : GEOREF

INTRODUCTION

16.1. In order that references to geographical positions may be speedily transmitted between allied forces a reference system, known as the "Geographical Reference System - (Georef)", was introduced. This system, simple in use and having a world wide application:-

(a) Abbreviated latitude and longitude references

(b) Obviates the difficulties and confusion arising from the use by allied ground forces of a variety of "grid" systems.

16.2. Georef is used by all forces directly engaged in the air defence of Great Britain, for example:-

(a) For plotting and telling positions of aircraft throughout the reporting system.

(b) For facilitating the control of fighters and guns.

(c) For passing positions of crashed aircraft to the air/sea rescue organization.

Description

16.3. Georef may be applied to any map marked in parallels of latitude and meridian of longitude.

16.4. Georef Division of the Earth's Surface. The Georef system divides the earth's surface into quadrangles, the sides of which are specific arc lengths of latitude and longitude. Each quadrangle is identified by a lettered code in such a way as to avoid ambiguity. The system and code are as follows:-

(a) 15° Quadrangles or "Primary Areas" (Fig. 1)

(i) There are 24 longitudinal zones each of 15° width, extending around the globe. These are lettered A-Z inclusive, eastward from the 180° meridian (see note).

(ii) There are 12 bands of latitude each of 15° depth around the globe. These are lettered A-M inclusive, northward from the south pole (see note).

(iii) The earth's surface is thus divided into 288 PRIMARY AREAS each identified by two letters, the first letter being that of the longitudinal zone, the second that of the latitude band.

(b) 1° Quadrangles or "Secondary Areas" (Fig. 2). Each 15° quadrangle is subdivided into:-

(i) $15 \times 1^{\circ}$ zones of longitude, each zone lettered from A-Q inclusive, west to east (see note).

(ii) 15 x 1° bands of latitude, each band lettered from A-Q inclusive, south to north (see note).

A secondary area anywhere on the earth's surface can be identified by four letters. The first two letters referring to the primary area, the third that of the 1° longitude zone, the fourth, that of the 1° latitude band.

(c) Four Figure Reference (Fig. 3). To obtain a four figure reference:-

(i) Each secondary area is subdivided into 60 minutes of longitude, numbered from west to east, and 60 minutes of latitude numbered from south to north.

(ii) The first two numerals of the reference are the numbers of minutes from west to east within the secondary area, the last two the numbers of minutes from south to north within the secondary area.

NOTE: The letters I and O are omitted from the code to avoid confusion with figures.

Georef Procedure

16.5. To give the position of an object (e.g. Salisbury Cathedral in Wiltshire) using the Georef system:-

(a) Indicate the letters of the primary area. Wiltshire is in the part of England in the primary area MK (Fig. 1).

(b) Indicate the letters of the secondary area. Salisbury is in the secondary area MKPG (Fig. 2).

(c) Obtain the four figure reference by indicating the number of minutes:-

(i) From west to east within the secondary area MKPG. This gives the first two figures - 12 (see Fig. 3).

(ii) From south to north within the secondary area MKPG. This gives the last two figures - 04 (see Fig. 3).

Thus the four figure reference is 1204. Therefore the Georef position of Salisbury Cathedral to the nearest minute is MKPG 1204.

16.6. Accuracy of Georef Positions. A Georef position is accurate to within:-

(a) One nautical mile when four letters and four numerals are quoted. Tracks are plotted throughout the C. & R. system to an accuracy of one nautical mile. The four-figure reference is therefore the one with which fighter plotters are mainly concerned.

(b) Five hundred feet when four letters and six numerals[*] are quoted. This reference is used for reporting positions of crashed aircraft to Police, Air Sea Rescue etc.

[*] Accuracy inside 500 feet is obtained, using large scale maps, by sub-dividing the minute quadrangles into 36 equal areas whose sides are 10 seconds long.

16.7. Techniques.

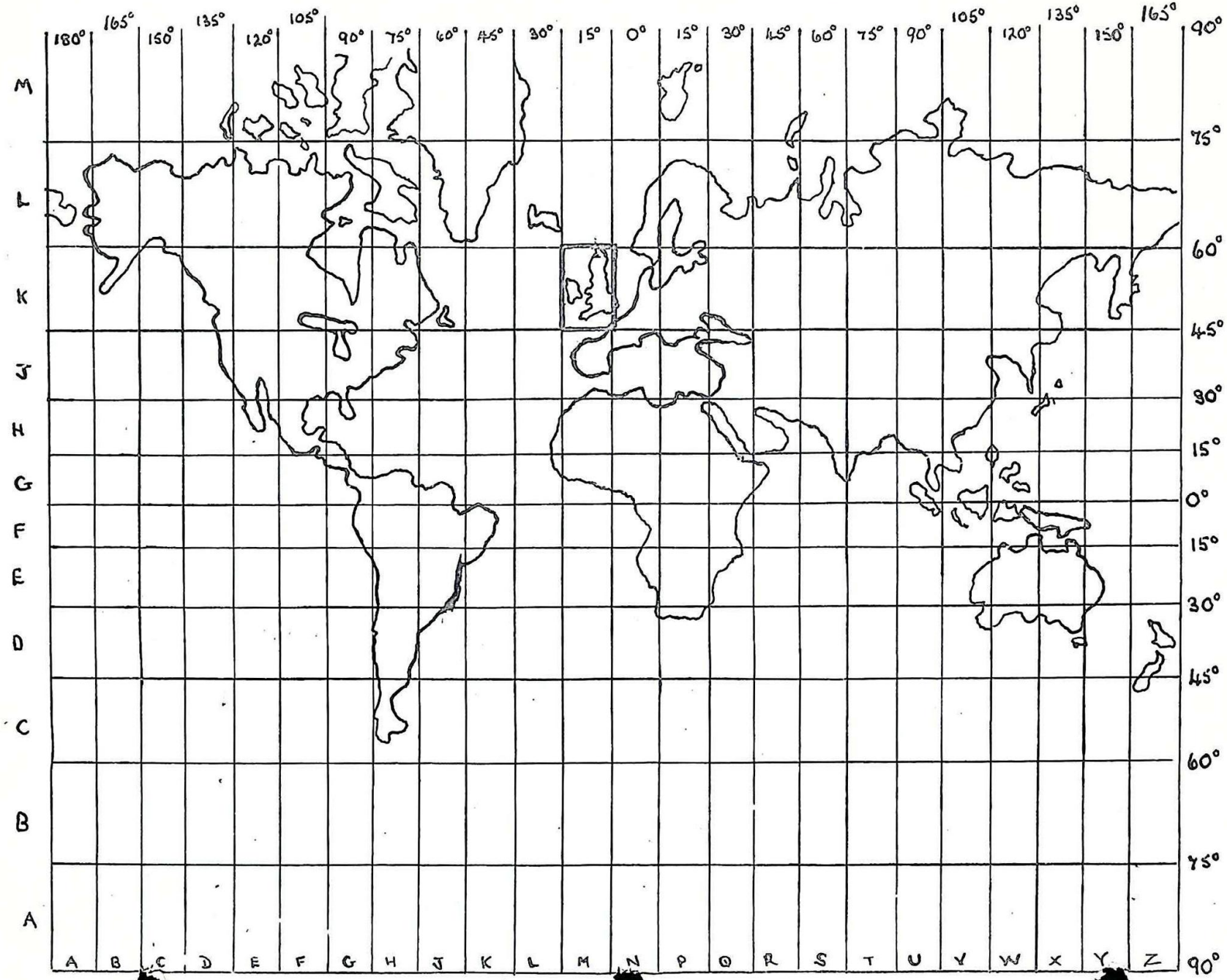
(a) Abbreviating the Plot. The reporting cover over the U.K. and its approaches is all contained within primary areas MK and NK. Thr first two letters indicating these primary areas can therefore be omitted providing it is sufficiently obvious which primary area is implied.

(b) Orbiting aircraft. When an aircraft is orbiting one position, only two letters and the first and third numerals need be told (e.g. PG 5-4-).

(c) Aids to familiarization.

(i) Each 1^{o} area is subdivided into 36 areas with sides of 10 minutes. These 10 minute intervals are marked 0-5 (Fig. 4) as an aid to quick determination of the first and third numerals. The second and fourth numerals are obtained by mental subdivision of each 10 minute area (example Fig. 4).

(ii) Remember that within each primary area, the first letter of each secondary area, reading vertically, is constant, and the second letter, reading horizontally is constant (Fig. 3).



15° Quadrangles or Primary Areas - Fig 1

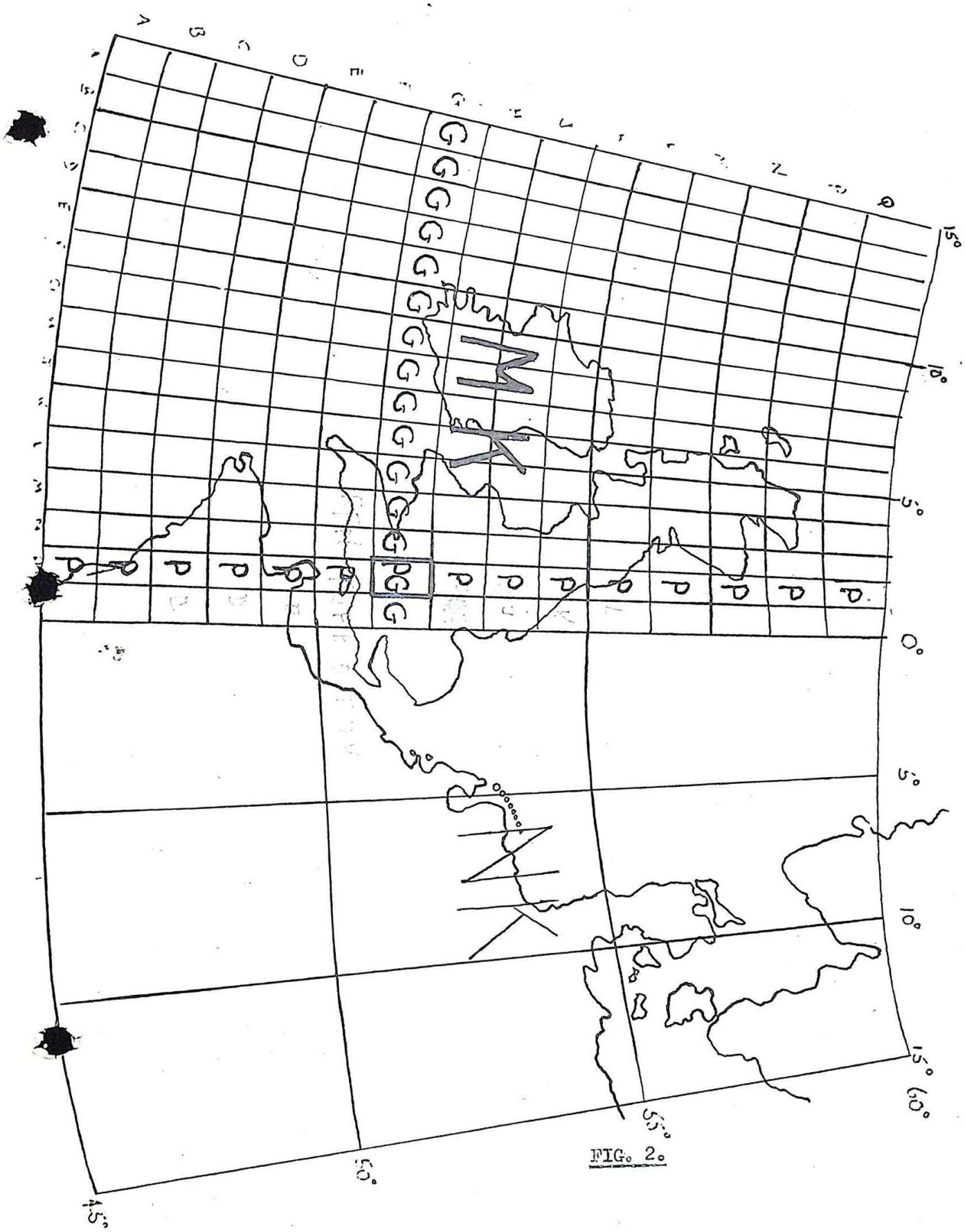
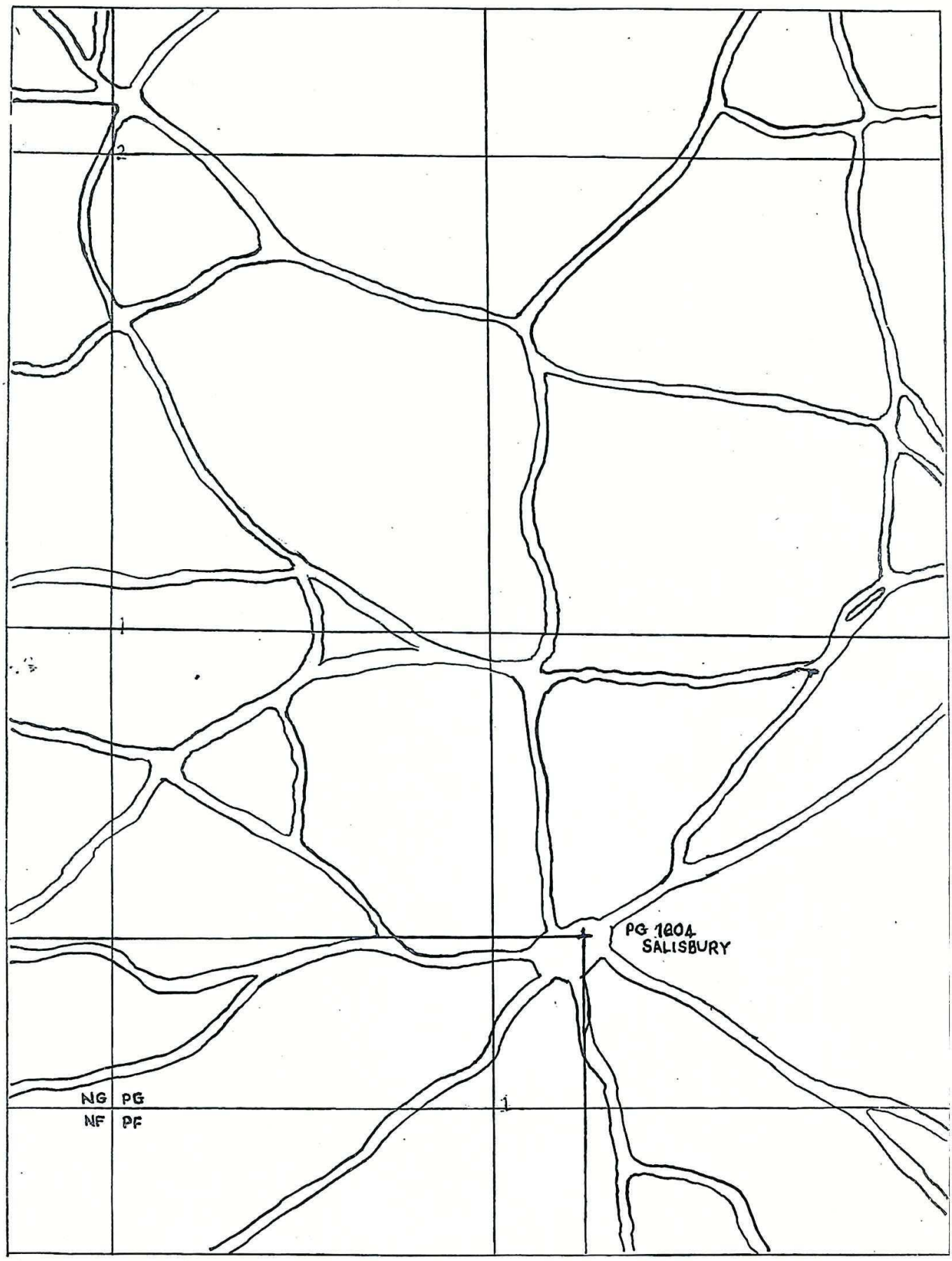


FIG. 2.

1° QUADRANGLES OR SECONDARY AREAS



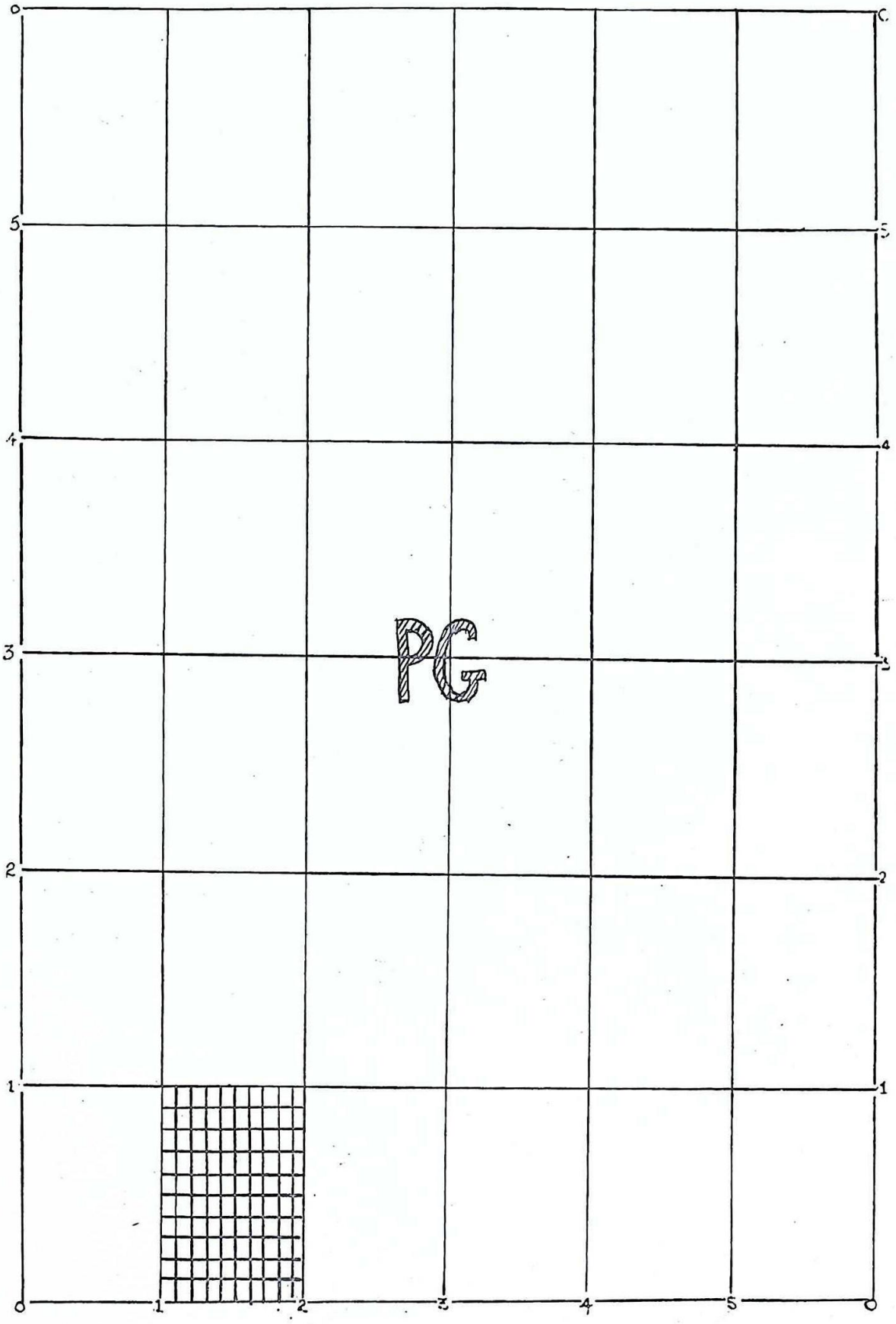
NORTH

EAST

READING OF GEOREF

FIG. 3.

FIG. 4. SUBDIVISION OF 10° AREAS



SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 17 : CHRONOMETRY IN THE C. & R. SYSTEM

Introduction

17.1. A specialized system of time measurement is adopted in the C. & R. system for reasons which will be explained in the following paragraphs.

The Time System

17.2. Indicating Time.

(a) Colour Clocks and Indicators (Figs. 1a and 1b). Synchronized clocks, marked in $2\frac{1}{2}$ minute colour periods, in the sequence RED - YELLOW - BLUE, are installed at A.D.O.C., S.O.Cs., G.C.Is. and C.C.F.Ps. In addition, colour change indicators which indicate the current colour period without indicating the actual time, are employed.

(b) Five Period Pulse Indicators (Fig. 1c). Five period pulse indicators are installed at C.C.F.Ps. They indicate 5 x $\frac{1}{2}$ minute periods during each colour period thus:-

(i) As each new colour period begins, number 1 pulse is indicated. It remains for $\frac{1}{2}$ minute.

(ii) Consecutive $\frac{1}{2}$ minute periods are indicated by pulses 2 - 3 - 4 and 5.

Use of Specialized Chronometry at the C.C.F.P.

17.3. Timing Plots on the Filter Table.

(a) Radar Plots. The time currency of radar plots is indicated by the use of numbered counters. Plots are numbered 1-5 inclusive, to accord with the number displayed by the pulse indicator at the time of receipt of the information.

(b) R.O.C. Plots. The time currency of R.O.C. plots is indicated by the use of coloured arrows. The arrow-tips are coloured.

(c) Initial Filtered Plots. An initial filtered plot on a new track is displayed by the use of a red, yellow or blue halma to accord with the colour period current at the time of receipt of the information.

17.4. Advantages to Filtering. The following examples illustrate how this timing system assists filter supervisors in producing a clear and current air picture:-

(a) When non-directional counters are used the general direction of the track (incoming or outgoing) can be determined by the numbers on the counters and their position on the table.

(b) Filter supervisors are enabled to filter ahead of the plotting counters, if the pulse indicated is an advance of the numbers shown on the latest counters displayed.

Use of Specialized Chronometry at S.O.Cs./G.C.Is. and A.D.O.C.

17.5. Timing Plots on the G.S.M.

(a) Colour change indicators are fitted to all G.S.M. tables

(b) Coloured plotting arrows are used to display tracks, the colour illuminated on the indicator denoting the colour of the arrows to be used for plotting at that time.

(c) Plotting arrows of any one colour remain in position until that colour recurs (i.e. between 5 and $7\frac{1}{2}$ minutes later) when they are removed.

17.6. Advantages to Control Users. The following examples illustrate the advantages of their timing method to the control users:-

(a) The user is assured that no track displayed is more than $7\frac{1}{2}$ minutes old.

(b) The user can assess the delay, and the probable position of a track by comparing the colour of the leading arrow with the current colour on the indicator.

Raid Removal

17.7. Raid Removal Tray. Raid removal trays are used at both filter and G.S.M. tables. The tray is coloured in sections, red - yellow and blue. When a track fades, the raid plaque is placed in the section of the tray indicated by the current colour. It remains there for a further complete colour cycle (in case the track should re-appear) prior to final removal.

Time Synchronization throughout the C. & R. System

17.8. Greenwich Mean Time is employed throughout the C. & R. system. In order to ensure that clocks and indicators at all units are synchronized, time checks are passed every two hours during watch periods by the Filter Officer from the C.C.F.P. Floor supervisors at S.O.Cs. and G.C.Is. check their times against TIM (the G.P.O. time relay system) independently.

Zone Times (A.P. 3184 Chap. 6, para. 19).

17.9. For time purposes the Earth is divided into zones each of which extends from pole to pole and covers 15° longitude. Adjacent zones differ by 1 hour and each is known by a letter. Thus:-

(a) G.M.T. (Greenwich Mean Time) is known as Z (Zebra time) and the:-

(i) 12 zones eastwards from the Greenwich zone are lettered from A-M inclusive (omitting "I").

(ii) 11 zones westward from the Greenwich zone are lettered Y-N inclusive (omitting "O").

(b) Standard Local Time. In the U.K. this may be either:-

(i) G.M.T. or Zebra time, or

(ii) B.S.T. (British Summer Time) or Able time (i.e. when clocks are put on one hour from G.M.T.).

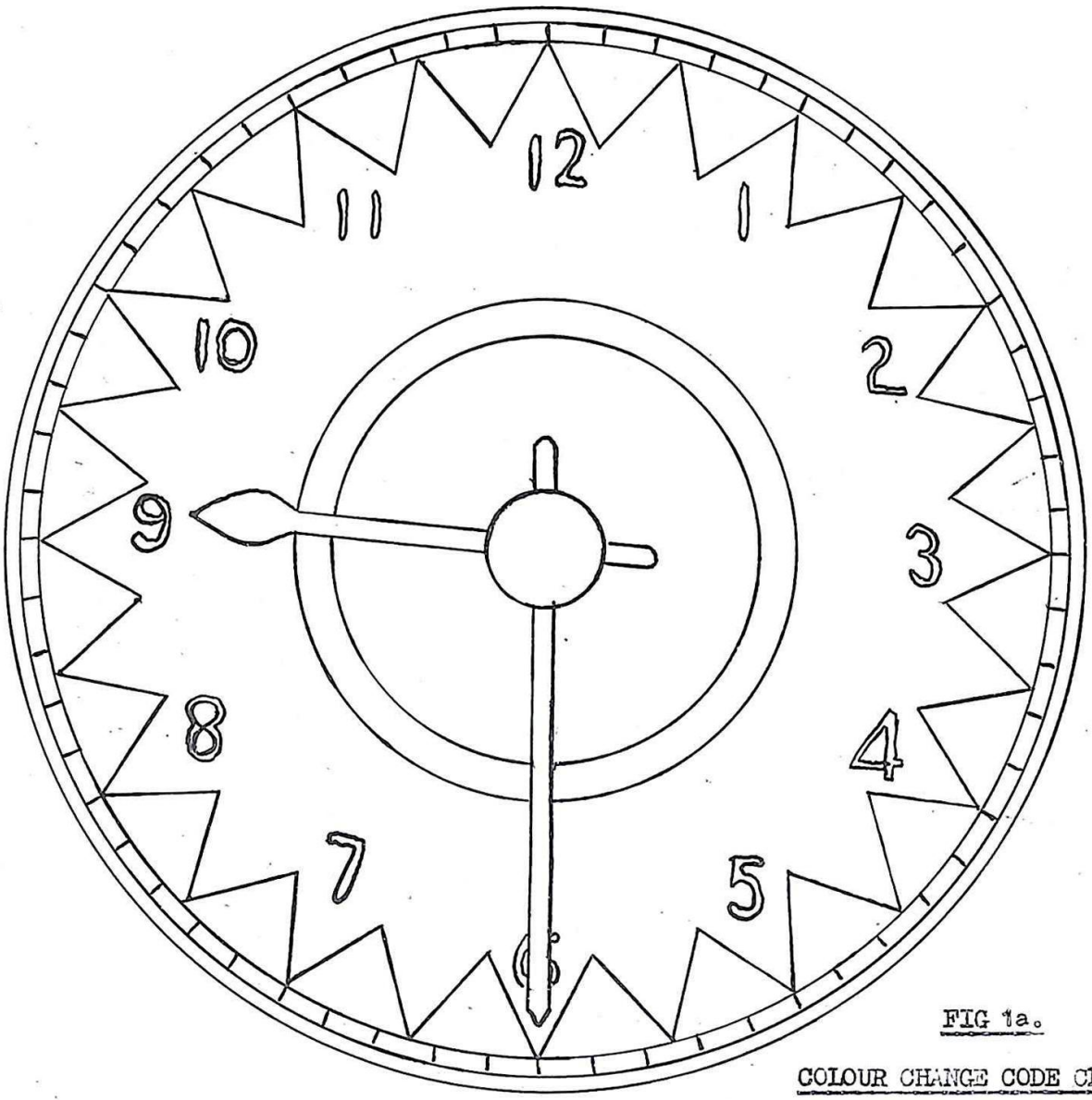
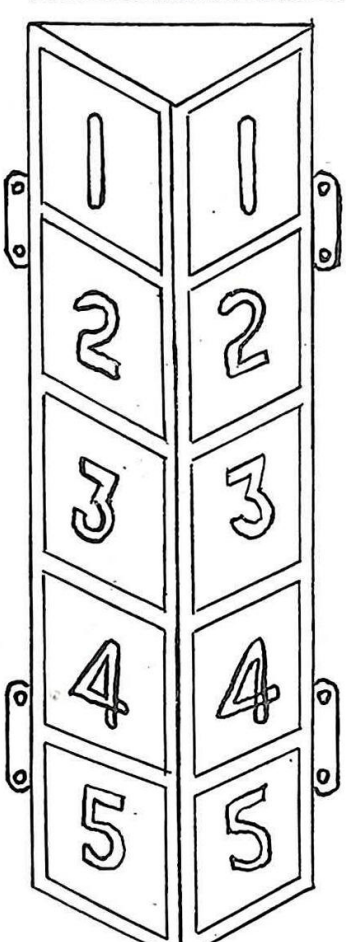


FIG 1a.

COLOUR CHANGE CODE CLOCK

TIME PULSE INDICATOR



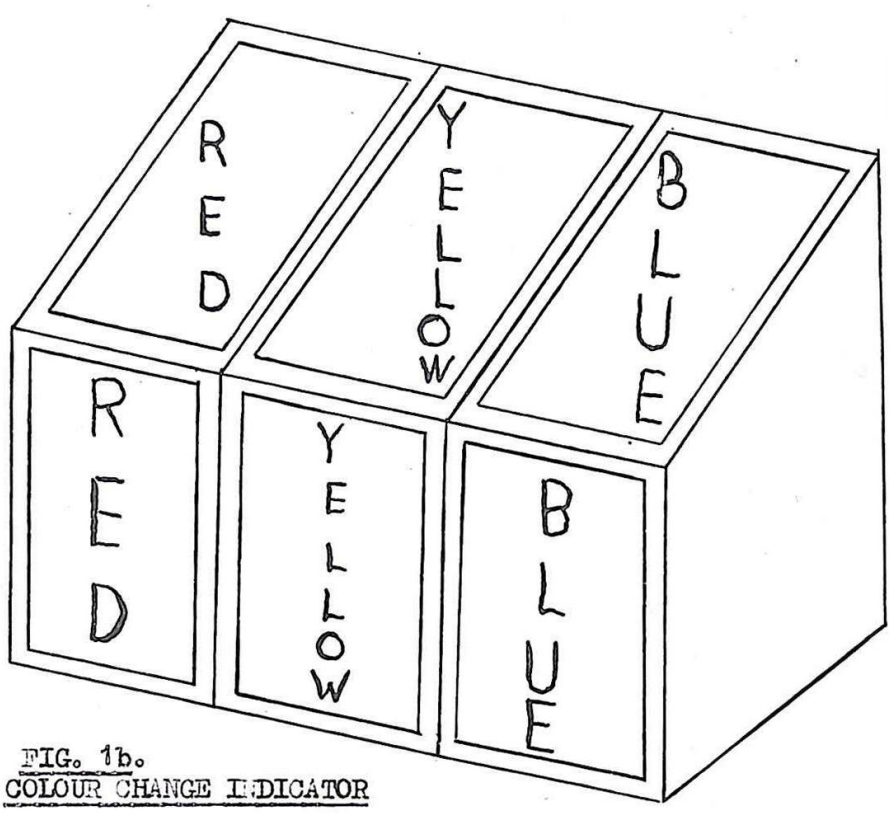


FIG. 1b.
COLOUR CHANGE INDICATOR

FIG. 1c. FIVE PERIOD PULSE INDICATOR

17.10. The correct method of indicating time throughout the C. & R. system is by use of either:-

(a) Zebra time (e.g. 1020 Z = 1020 G.M.T.) or,

(b) Able time (e.g. 1020 A = 1020 B.S.T.).

SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 18 : FILTER TABLE DISPLAYS

INTRODUCTION

18.1. In order to produce a picture of air operations within each Sector area, which is complete, accurate and free from duplication, information from reporting sources is displayed and refined on filter tables at the C.C.F.P., whence it is told out to the G.S.Ms. The equipments, procedures and techniques employed for this purpose are covered by the following paragraphs.

FILTER TABLE

18.2. Each filter table supports a horizontal map of a distinct area, the areas together composing the territory of the entire Sector plus 20-30 mile overlap into adjacent Sectors.

18.3. Construction of the Table.

(a) The Sector territory is divided so that each table receives reports from a convenient number of sources and the tables are generally non-symetric in shape.

(b) Around the table is a shallow ledge on which plotting equipment is kept.

(c) Reporting landlines terminate at double jacks positioned around the edge of the table to allow:-

(i) Plotters to receive information

(ii) Plotters to reach the displayed operating areas of their respective reporting sources

(iii) Two plotters to operate on one position during periods of intense air activity.

18.4. The Map. The horizontal map of a typical filter table shows:-

(a) Georef graticules

(b) Overlaps boundary lines

(c) Position of radar stations - each station marked in a distinctive colour

(d) Range circles

(i) spaced 20 nautical miles apart around each C.H. station, each circle clearly marked 20, 40, 60, etc.

(e) Line of shoot - of each C.H. station, marked in that station's colour.

18.5. Plotting equipment is designed:-

(a) In various shapes, each shape indicating the type of information conveyed (i.e. height, strength or plan-position).

(b) With various markings indicating the type of R.R.U. reporting

(c) In different colours, each colour representing the particular R.R.U. reporting.

18.6. Plan Position Counters:-

(a) Non-directional counters:- These are used to indicate:-

(i) All C.H. plots

(ii) Initial plots from metric/centimetric stations.

(b) Directional counters. Used to indicate directional plots by one or other of the eight cardinal points of the compass (i.e. N., NE., E., SE., S., SW., W., NW.).

18.7. Area Counters. Used when area plotting is ordered:-

(a) C.H. - used to indicate inner and outer ranges of a raid.

(b) Metric/Centimetric - used to indicate the four corners of a raid.

18.8. I.F.F. Counters.

(a) These are used to indicate that I.F.F. responses have been observed (see Precis 12) indicating:-

(i) friendly identity, in which case the IF counter is used, or,

(ii) that an aircraft is in distress, in which case the S.O.S. counter is used.

(b) I.F.F. reports from C.H.B. reporting sources will be of fighter aircraft fitted with MK III G. IFF either (i) identifying themselves to G.C.I. stations (when the IF counter is used) or (ii) transmitting distress signals when the S.O.S. counter is used.

18.9. Height Counters. These are used in the following way:-

(a) Numbered counters indicating height in thousands of feet.

(b) + = above

(c) - = below

(d) NH = No height obtained.

18.10. Strength Counters

Numbered 1, 2, 3, 3+, 6+, 9+, 15+, 25+, 50+, 100+.

18.11. Track Numbers

(a) Diamond shaped, numbered 0-9 inclusive to coincide with last numerals of track serial number.

(b) Used to differentiate between plots in tracks in close proximity.

18.12. Fade Plaques. The station plotting colours and equipment types are to be shown on the fade plaque.

18.13. Rat Plaque. A red square is placed against each plot on "RATS" tracks - a magnetic red counter is placed by the filterer.

Filter Equipment

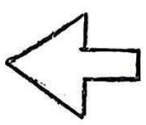
18.14. At the time of writing the following equipment is in use:-

(a) Halmas  Coloured red, yellow, blue for use with colour clock.

(b) Plotting arrows

(i)  White heart shaped arrows indicate first two directional positions.

(ii) Coloured heart shaped arrows indicate change of ancillary information.

(iii)  Coloured arrows indicate subsequent filtered positions.

(c) Raid Plaque (Precis 3, para. 5)

(d) Mass Raid Equipment. (See appropriate F.C.C. & Proc. Instruction).

(e) Raid Removal Tray, one third of which is coloured red, one third yellow, and one third blue. Raid plaques of faded tracks are placed in the appropriate colour section (as indicated by colour clock).

PROCEDURES AND TECHNIQUES

18.15. Plotting (including Raid Orderly) Procedures as detailed in F.C.C. & R. Proc. Instructions must be strictly adhered to at all times.

18.16. Plotting Techniques.

(a) The tellers' view of the table is less obscured by plotters using short wooden sticks, with rubber and attachment to manipulate the counter in the parts of the table out of normal reach from a sitting position. When positioning a direction counter it should be placed in front of the plotter pointing in the required direction, and pushed into position in one clear movement with the plotting stick.

(b) Speedier plotting can be carried out when the counters are left in a tidy and strict sequence on the plotters trays provided. (e.g. counters 1, 2, 3, 4 and 5 left in separate sequented compartments. Students should memorize the order in which counters are left in their trays so that, in time it becomes unnecessary to look at the tray to find the counters required.

(c) Each student should familiarize himself, with the filter-tables at his C.C.F.P. Memorizing the "georef graticules" on each table, will enable the plotter to look without delay to that part of the table indicated by the letters of the plot.

(d) A C.H. station plotter may sometimes assist the filter supervisor in the positioning of a track by range cutting methods by:-

(i) Noting when an adjacent C.H. station reports a track at long range.

(ii) Informing his station of the approximate range of the raid (a weak response may be overlooked at extreme range by the radar observer) in an endeavour to obtain a range which will indicate more accurately the position of the raid.

Filter Procedures

18.17. Filter Procedures as detailed in the appropriate F.C.C. & R. Proc. Instruction should be studied by all fighter plotters to enable them to:-

(a) Understand more fully the uses to which their many reports are put.

(b) Become an effective member of a "team" which will produce the best possible picture of activity on their respective tables.

18.18. Filter Techniques

(a) Identity. When plots from different R.R.Us. fall close together on the table, the filterer must decide whether they apply to the same, or different raids.

(i) His task is simplified when directional plots are displayed, as any discrepancies are due either to bearing or calibration errors of the R.R.Us. These can be quickly checked by the Filter Officer who requests the stations to calibrate.

(ii) Decision is more difficult when non-directional plots only are displayed. Then the filterer must make his decision using "range out methods" (see (b)(iii)) and be prepared to make rapid adjustment of any errors shown in the light of subsequent information.

(b) Plan Position. To obtain a plan position the filter supervisor may accept any one, or a combination of, the following:-

(i) Plot received from a source using P.P.I. displays

(ii) A plot from one C.H. station (successive plots giving a hint of the track's direction by the range-opening, closing or remaining constant).

(iii) "Range cuts" of plots from 2 or more C.H. stations in the same aircraft (i.e. using the range circles to find the intersecting point of the various ranges indicated by the plots). It is usual for the filterer to "advance" the filtered positions to compensate for time delays of reports reaching his table.

(c) Direction of Flight. Having filtered 2 or more successive positions on a track, direction of flight can always be indicated. Moreover, P.P.I. equipped stations generally give direction with their second and subsequent reports on a track.

(d) Height.

(i) Type 7 and 13 heights are generally assumed by the filterer to be fairly accurate. C.H. reports vary in accuracy, and are therefore checked against other height information reported on the same track, whenever possible.

(ii) On long range reports, of over 200 miles, stations seldom pass heights. The filterer is expected to estimate a "pick up" height using specially prepared charts (V.P.Ds.) showing the vertical coverage of the R.R.Us. reporting to his table.

(e) Strength. R.R.Us. reports of raid strength differ because of differing:-

(i) site position - a raid approaching "A" station will be "seen" front to rear, whereas "B" station sited some distance away might see across the raid - thus length and breadth strength will be indicated to the filterer.

(ii) station performance - a raid in depth may possibly be seen partially by low cover stations and partially by medium/high cover stations.

By comparing the various reports and having a knowledge of (i) and (ii) above, the filterer is enabled to assess the strength of a raid fairly accurately.

Telling and Recording Procedures

18.19. The telling and recording procedures detailed in the appropriate F.C.C. and Proc. Instruction must be strictly adhered to at all times.

SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 19 : G.S.M. DISPLAYS

Introduction

19.1. The equipment procedure and techniques employed display the air picture received from the C.C.F.P., are described in the following paragraphs.

Equipment

19.2. G.S.M. Table

(a) The table shows a map (usually octagonal in shape), which is set at a low sloping angle in order to present a clear view of the display to the users.

(b) Spaced around the edge of the table are fixed double telephone jacks.

(c) A narrow channel around the edge of the table is used to store the display plotting arrows.

(d) A colour change indicator is usually fitted on the table within the view to all plotters and users.

19.3. General Situation Maps. The map shows:-

(a) At S.O.Cs.

(i) The area of the sector and its approaches from all directions.

(ii) Sector boundary lines.

(iii) Gun defended areas (G.F.As.).

(b) At G.C.I. stations. Although features similar to those at S.O.Cs. generally in larger scale and the area displayed covers the approaches to the G.C.I. station.

(c) Air Defence Operations Centre

(i) The whole of the British Isles and their approaches.

(ii) All sector boundary lines.

NOTE 1: The following information may also be displayed:-

(i) Fighter aerodromes

(ii) Radar stations

(iii) Important towns.

NOTE 2: All G.S.Ms. are marked with the GEOREF graticules.

19.4. Plotting Equipment. The equipment used in displaying the C.C.F.P. track information is:-

(a) Plotting Rod. Because of the size of the G.S.Ms. and the need to provide an uninterrupted view to the users plotting rods are used to manipulate the arrows and raid plaques into position on the table. The rods are supplied in various lengths and embody:-

(i) A magnetic head to manipulate the metallic arrows and ancillary information plaques into position.

(ii) A clip for the positioning and easy removal of the raid display stands.

(b) The Plotting Arrows. Small metallic arrows, coloured red, yellow or blue, are used to display the plots passed from the C.C.F.P., the tip of the arrow indicating the pinpoint position of the track. Different coloured arrows are used in sequence to correspond with those shown on the colour change indicator.

(c) The Raid Display Stand. Information relating to each track is displayed by means of a shallow serially numbered metal stand, into the slots of which fits the metallic plaques indicating the ancillary information.

Plotting (including Raid Orderly) Procedures and Techniques

19.5. Plotting Procedures as detailed in the appropriate F.C.C. & R. Procedure Instruction must be strictly complied with at all times. Diagram from the laid down procedures (other than those variations ordered locally by the Sector Commander concerned) will tend to confuse the user and so cause delay in initiating action.

19.6. Plotting Techniques. The following techniques will be of assistance to the student in increasing his plotting speed and proficiency.

(a) Studying the G.S.M. The student should on first manning a position on the G.S.M. study it. This will enable him on hearing the first two letters of a Georef plot to look instinctively in the right direction.

(b) Use of the Plotting Rod. When using the plotting rod the position arrows or ancillary information:-

(i) draw back the arm holding the trigger action, downward and backwards to its full extent thus bringing the magnetic head in front of the body.

(ii) press the trigger and, with the other hand, position the arrow or plaque on the magnetized head of the rod in such a way that it can be placed with the correct position from whatever angle the plotter is working.

(c) Tracks Within Arm's Reach. When tracks are plotted within arm's reach of the plotter, he should plot by hand in order to increase the speed of plotting.

(d) Arrow Trays. Keeping the plotting arrows in the correct colour sequence in the trays provided will enable the plotter to pick up the arrow required without diverting his attention from the G.S.M.

(e) Co-operation. As one raid orderly normally serves 3 or 4 plotters, the plotters and raid orderly should learn to work together, the plotters giving clear and concise orders for equipment. Should the equipment required be close to hand, the plotter should help himself.

(f) The plotter should always keep careful watch for tracks approaching his plotting area from adjacent areas, thus anticipating the telling of these "new" tracks over line from the C.C.F.P.

SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 20 : TOTES

INTRODUCTION

20.1. The following paragraphs describe those displays which are individually and jointly referred to as a Tote. Tore displays are used to record information covering the air battle. At each level in the control organization only those tote displays appropriate to that level are used. The information displayed in this way includes:-

(a) States of preparedness of fighter squadrons.

(b) Missions bring flown by fighters.

(c) A.A. Gun control orders in force within gun defended areas.

(d) Serviceability of fighter bases.

(e) Weather conditions.

(f) Serviceability of control radars.

(g) Certain other information which will be referred to in Precis 27.

TOTE DISPLAYS

20.2. Totes are maintained by fighter plotters at the A.D.O.C. at S.O.Cs. and G.C.I. stations. Most of them consist of narrow horizontal slats built into a large framework facing the users. Display in these cases effected by slotting "hook-on" symbols onto the slats from the rear of the framework. On these displays on which changes are infrequent, chalk is used to display the information.

20.3. S.O.C. Tote Displays. The tote at the S.O.C. is used to display the following:-

(a) Squadron States (Fig. 1). The states of preparedness of all squadrons, within the sector are shown. Separate All Weather and Day Totals.

(b) Missions (Fig. 2). Details of missions being flown by fighters of the sector are given.

(c) H.A.A. States (See Precis 9, Fig. 1). The gun control orders in force in the G.F.As. within, or adjacent to the sector boundaries are displayed.

(d) Airfield States (Fig. 3). The serviceability of the fighter bases within the sector is shown.

(e) Serviceability of Control Radar (Fig. 4). This board is used to show the state of serviceability of control radars within the sector.

20.4. G.C.I. Stations' Tote Displays. The tote at a G.C.I. station are used to display the following:-

(a) Missions. Details are shown of missions being flown by fighters under that station's control.

(b) A.A. States. This is a replica of the H.A.A. display at the S.O.C.

(c) Airfield States. As for Sector (see para. 3(d)).

(d) Weather Board. Meteorological information is received every few hours and is displayed on this board (and weather boards in the interception cabins). This information is necessary for the resolving of navigational problems affecting interceptions.

20.5. Air Defence Operations Centre Tote. The tote at A.D.O.C. is used to display the following:-

(a) Aircraft States. This display shows the current totals of aircraft (and crews) at various states of preparedness in each sector.

(b) Missions. Missions being flown by fighters of all sectors are displayed.

(c) Airfield States. The serviceability of all fighter bases throughout the U.K. is shown.

DESCRIPTION OF DISPLAYS

20.6. Squadron States Display. This display is designed to show the states of preparedness of up to 30 squadrons, and is divided into four sections:-

(a) First Section (Left)

(i) RLS - Aircraft (and crews) released for a period by the sector controller.

(ii) On call 30 minutes.

Columns (i) and (ii) show totals of aircraft not readily available for operations.

(b) Second Section

(i) Base.

(ii) Squadron number.

(iii) Callsign (see Note 1).

(iv) Type of aircraft.

(c) Third Section

(i) Available 10 minutes.

(ii) Ordered to readiness.

(iii) Readiness 5 minutes.

(iv) Ordered to standby.

(d) Fourth Section

(i) Standby 2 minutes

(ii) Ordered off.

(iii) Total airborne.

(iv) Total turnround - indicating aircraft landed and refuelling, rearming, etc.,

NOTE: A 'WING' callsign allotted to each fighter wing is included in this column.

20.7. Missions. This display is divided into the following columns:-

(a) Serial Number. For quick reference, each mission is allotted a serial number by the S.O.C., by which it is known until that mission is completed. Allocation of consecutive numbers, beginning at one, and ends at the following midnight.

(b) Callsign. (Of each unit/formation - see para. 16)

(c) Time airborne.

(d) Mission.

(e) Control. This is usually an abbreviation of the G.C.I. station controlling the mission (e.g. WG-Wartling). Sector Fighter Marshal and local airfield control is not (usually) shown, as the channel indicates this.

(f) Channel. This is the V.H.F. channel being used to control the mission.

(g) Remarks. This column is used for the inclusion of relevant information other than that which may be included in the other columns.

NOTE: The mission tote at G.C.I. stations is divided into horizontal sections. A section is allotted to each cabin, including the fighter marshal's for the display of information applicable to the mission being flown.

20.8. Airfield States Board. This board is divided horizontally into sections (a section to each fighter base) and displays the following:-

(a) Airfield Serviceability State. This is shown as

(i) Green - fully operational.

or (ii) Yellow - operational in emergency.

or (iii) Red - non-operational.

(b) Weather Conditions. The weather prevailing at each base is shown under the following headings:-

(i) Visibility. This is displayed either in yards (if less than 2 miles) or in miles.

(ii) Cloud. Cloud amount is passed in eights or $\frac{1}{8}$ths with the height of the base shown alongside (in 1000's of feet).

(iii) Surface Wind Velocity. The direction the wind is blowing from and its speed in knots (e.g. 310^{0} - 10 KNTS).

20.9. A.A. States Board. This is fully described in the appropriate F.C. Proc. Instructions.

Sources of Tote Information

20.10. Squadron and Airfield States Displays. Information to be displayed is received either over the intercom from the air executive assistant or direct from wing operations rooms.

20.11. Missions Tote at S.O.C. Details of missions are received from:-

(a) Control executives assistant. He is responsible for passing all relevent details of missions as they are initiated by the control executive.

(b) Wing Operations Rooms. The times at which fighters become airborne or land are given and details of local flying (training, testing etc., not directly concerned with the air battle).

20.12. Mission Tote at G.C.I. Stations. Details of missions allotted to a particular G.C.I. station are passed by the control executive's assistant to the chief controller's assistant, who in turn relays them to the tote operator at the G.C.I. stations.

20.13. A.A. States Board. Details of H.A.A. control orders are broadcast to all H.A.A. states boards throughout the sector by the H.A.A. executive.

20.14. A.D.O.C. Tote. Information is passed direct by - a tote teller at each sector to the tote operators at A.D.O.C. Details of the method of passing this information are fully described in the appropriate F.C. Proc. Instructions.

PROCEDURES AND TECHNIQUES

20.15. Squadron States Display.

(a) Figures are used to denote the numbers of aircraft at various states of preparedness.

(b) A squadron airborne as a single formation is to be displayed as a squadron and not a collection of Section colours.

(c) As aircraft are brought up to new states of preparedness the numbers are moved along the tote in the correct columns (marked also on the reverse side of the display) and the numbers in the previous columns are amended accordingly.

EXAMPLE: 16 a/c are shown as "on call 30 mins.".

ORDER: "Bring 4 a/c to 10 mins. available".

ACTION: Hook a figure 4 in the AVL 10 MINS" column and change the number in the "ON CALL 30" column to 12.

20.16. Missions.

(a) As details of a mission are received, the Sector Tote operator inserts the appropriate details with aircraft totals on the horizontal slats against the next consecutive serial numbers.

(b) Formation symbols (see para. 20(d)) are used with callsigns to indicate strengths of formations on each mission (see Appendix "A").

(c) "All Weather" fighters are indicated by using the squadron callsign and the pilots' squadron number (e.g. OFFSET 14).

20.17. Airfield States Board. A plaque of the appropriate colour is shown against each airfield.

20.18. H.A.A. States Board. The procedure for operating this display is given in F.C. Proc. Instructions.

TOTE EQUIPMENT

20.19. Squadron States. The plaques used on this display are the figures 0-9 painted black on white background for day and white on black for night and all weather squadrons.

20.20. Missions.

(a) Serial numbers, times, and pilots' squadron numbers are made up of individual figures painted white on black.

(b) Hostile and unidentified raid plaques and serial numbers are made up of individual letters and figures painted black on yellow.

(c) Callsigns, missions, controlling station and channels are either painted in full on hook on plaques or individual letters are used. They are painted black on white.

(d) Formation Symbols.

(i) Pairs or Sections — SEC

The background is coloured, the colours of pairs or sections being:-

RED, YELLOW, WHITE, PINK
BLUE, GREEN, BLACK, BROWN

(ii) Flight. — FLT

The background is coloured either:-

RED ("A" FLIGHT) or BLUE ("B" FLIGHT).

(iii) Squadron — SQDN

Coloured black on white background

(iv) Wing — WING

Coloured white on black background.

20.21. H.A.A. States Board.

(a) Control orders. These are indicated by use of hook-on plaques coloured either red, yellow or green.

(b) Height restriction. These are indicated by hook-on plaques with black figures (representing thousands of feet) on white background.

20.22. G.C.I. Weather Board. This is usually a blackboard marked in sections. Met. information is displayed in the appropriate section by use of chalk.

Appendix "A" to Precis 20

STANDARD FIGHTER COMMAND PROCEDURE FOR NAMING SQUADRON SUB-DIVISIONS

1. Throughout the Command the following terms are to be used:-

(a)	Two aircraft	- Pair
(b)	Four aircraft	- Section
(c)	Two sections	- Flight
(d)	Three or more sections of any one Squadron	- Squadron
(e)	Two or more squadrons	- Wing

2. Sections within a squadron will be designated by a colour code with the various colours being assigned as follows:-

(a)	"A" FLIGHT	Red Yellow White Pink
(b)	"B" FLIGHT	Blue Green Black Brown

3. Individual members of a section will be designated by numbers 1, 2, 3, and 4 as appropriate to his position within the section.

4. When sections are split into pairs both pairs will retain their original section colour and numerical designations (e.g. Red 3, Red 4).

5. Pairs operating as a pair from the commencement of a sortie will be designated by a colour code as if they were a section. Individual members will be designated by appropriate numbers.

6. All radio transmissions will be prefixed by the squadron callsign followed by the section colour and numerical designation (e.g. Falcon - Red 3).

7. When a single aircraft is returning alone from a sortie the pilot will continue to use his squadron callsign and section colour and number (e.g. Falcon - Red 4).

SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 21 : FIGHTER SCREENS AND TABLES

INTRODUCTION

21.1. In order that the users may see the progress of missions in which fighters are engaged, separated from other air activity, displays known as "Fighter Screens" or "Fighter tables", are provided.

21.2. Fighter screens are situated at G.C.Is. and are used to display tracks of fighters controlled by the various interception controllers and the fighter marshal or sector fighter marshal.

21.3. Details of the "fighter picture" displayed on G.C.I. fighter screens are passed to the S.O.C. where they are displayed on the sector fighter table.

FIGHTER DISPLAYS AT G.C.I. STATIONS

Fighter Screen

21.4. The G.C.I. stations fighter screen is usually positioned vertically in the centre of the "tote" displays and comprises a large transparent area of perspex on which is engraved:-

(a) A map (with associated "Georef") of the Sector area and parts of adjacent sectors.

(b) Sector boundaries.

(c) Gun fire areas.

(d) Fighter bases.

21.5. Plotting Equipment. Plastic (stick-on) arrows are used to display plan-position of fighters and targets, on the vertical screen, one arrow being used for each track:-

(a) Fighter track. A white arrow with a black number on tail is used; numbered 1-6 inclusive, the numbers denote the cabin controlling the fighters.

NOTE: Fighters controlled by Fighter Marshal are denoted by arrows with "M" on tail.

(b) Target track. Yellow arrows are used with black numbers on the tail (the number denoting the cabin controlling the interception).

(c) Combined Fighter/Target Track. Yellow stripes on the head of a white arrow denote a combined track.

(d) Fighters controlled by other G.C.I. stations are denoted by arrows of other colours.

21.6. Ancillary Information. A section of the G.C.I. Mission Tote (see Precis 20) is allotted to each cabin (including the fighter marshal's) for the display of relevant ancillary information.

Sector Fighter Table

21.7. Each G.C.I. fighter screen teller is connected by landline to a plotter at the sector fighter table. The table, similar to fighter tables used at G.C.Is. but with larger overlap areas into adjacent sectors, is positioned in the display hall directly in front of the sector controller and his executive staff.

21.8. Plotting Equipment. The following equipment is used to display the fighter mission picture:-

(a) Plotting Arrows.

(i) Metal plotting arrows in various colours are used to indicate plan-position of fighters and targets.

(ii) A separate colour is allotted by sector to each G.C.I. Thus the colour of the plotting arrows on tracks of fighters and targets indicates the G.C.I. controlling the different interceptions.

(iii) One arrow only is used on each track this being moved along to indicate each new plan-position.

(b) Plotting Rods. (see Precis 19)

(c) Raid Plaques (Fig. 1). These are made of metal and are easily manipulated with the plotting rod.

(i) Fighter plaque.

NOTE: A night fighter is indicated by use of the pilot's individual callsign number.

SIGHTING REPORTS

21.9. Wherever the aircraft being intercepted are recognized as of a certain type, this information is displayed on the fighter displays at the G.C.I. and S.O.C. concerned.

NOTE: Where no positive identification is available, the letter T (indicating "target") is used in place of the identity and serial number.

PROCEDURES AND TECHNIQUES

21.10. Procedures. The procedures for "fighter plotting and displays" are detailed in the appropriate F.C. Proc. Instruction and must be strictly adhered to at all times.

21.11. Fighter Screen Plotting Techniques. There are two types of display - vertical and horizontal:-

(a) G.C.I. Fighter Plots - Horizontal Display. When a horizontal table is employed, display of "type" of aircraft is to be done by substituting symbols depicted in Fig. 2 for target prefix to the serial number.

(b) G.C.I. Fighter Plots - Vertical Display. Where a vertical screen is employed, identification is to be written in chinagraph.

(c) S.O.C. Fighter Plots - Horizontal Display. Method described in subpara. 11(a) is to be used.

SECTOR FIGHTER TABLE DISPLAY PLAQUES

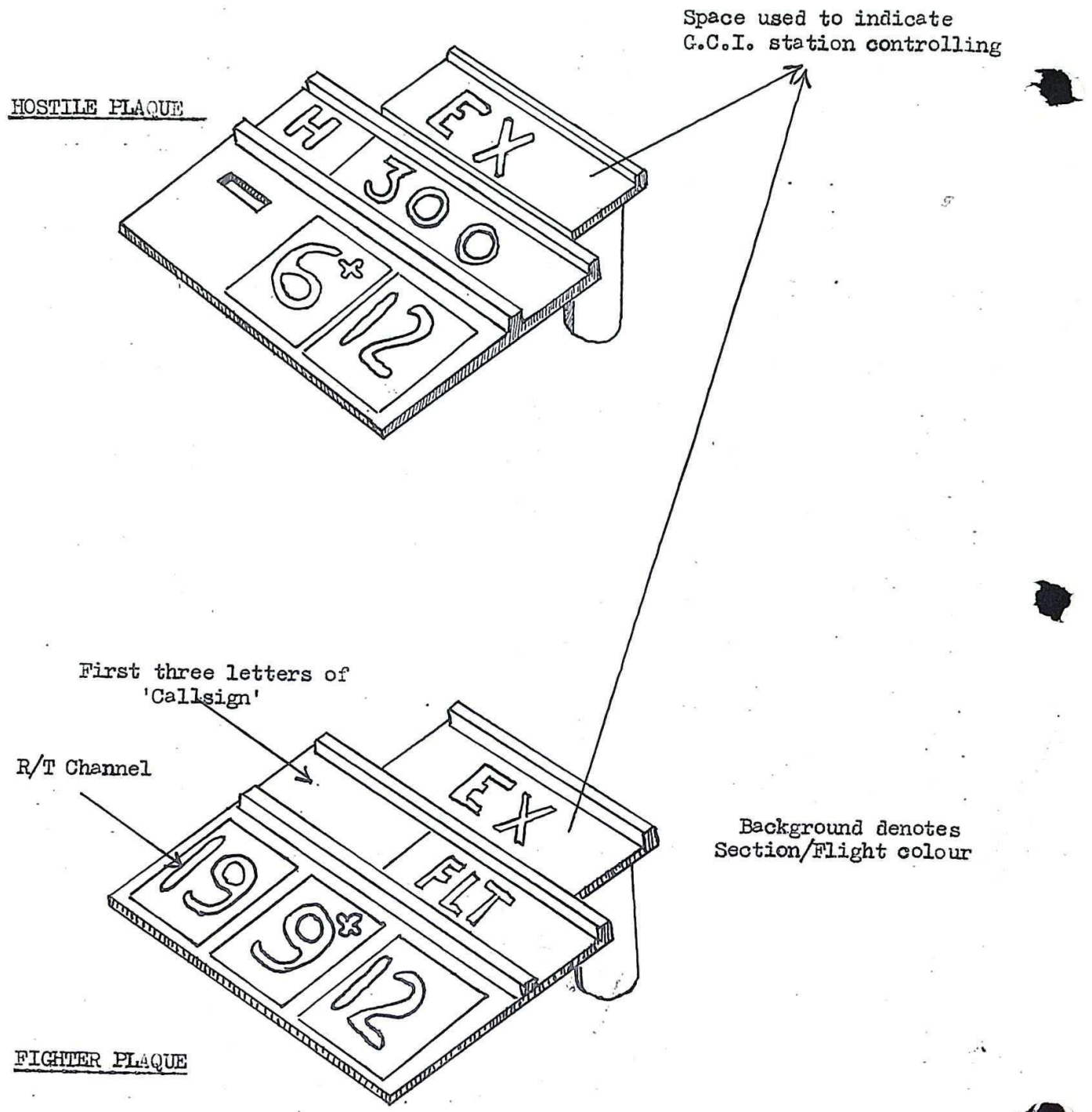


FIG. 1.

SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 22 : FORMS USED IN THE CONTROL SYSTEM

INTRODUCTION

22.1. The difficult conduct of operations requires that there should be some documentation of orders and information passed between the various levels of the control system. Certain forms, known as Forms A, B, C and D2, are used for this purpose. The use of each of these forms is described in the following paragraphs.

USERS AND PURPOSES OF FORMS

22.2. Form A. This form used at the A.D.O.C. and S.O.Cs. provides an accurate timed record of orders given by the A.D.O.C. and the resulting action by the S.O.C. Such a record is useful for:-

(a) Subsequent perusal

(b) Ensuring that action implementing the orders is carried out without delay.

(c) Statistical analysis when re-inforcement is ordered.

22.3. Form B. Form B, used by Wing Operation Rooms, S.O.Cs. and the statistical officer at Headquarters Fighter Command, provides information concerning the number of aeroplanes held, the number serviceable, the number of aircrew(s) held and the number available for operations. Such a record is useful for:-

(a) Indicating that replacements of aircraft and aircrew(s) are required.

(b) Indicating the degree of aircraft unserviceability.

(c) Statistical analysis.

22.4. Form C. This Form, used only at S.O.Cs. provides an accurate timed record of orders to scramble, orders changing states of readiness and the action taken within the S.O.C. and at wing operations rooms to implement these orders. Such a record is comparable in purpose with the records made on Form A.

22.5. Form D.2. This form, used by the A.D.O.C., S.O.Cs. and Wing Operations Rooms, is used for all operational messages following outside the scope of Forms A, B and C.

PROCEDURES

22.6. The procedures for use of Forms A, B, C and D.2 are given in the appropriate Fighter Command Procedure Instruction.

SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 23 : RAID RECOGNITION

INTRODUCTION

23.1. All tracks reported to C.C.F.Ps. with the exception of "visual" reports from the R.O.C. initially have no identity. At each C.C.F.P. an officer, known as the Raid Recognition Officer (R.R.O.) is responsible for deciding the identity of these tracks.

23.2. There are several distinct principles involved in the act of recognition, and it is usually by applying a combination of these that a decision is reached.

23.3. This precis describes the techniques and procedures adopted by the R.R.O. in his vitally important task of raid recognition.

23.4. Terms "Recognition" and "Identification". These terms are commonly (but wrongly) used synonymously:-

(a) "Recognition". This is the determination, by any means, of the friendly or hostile character of another force.

(b) "Identification". This describes the act whereby one makes one's friendly identity known to one's own forces (e.g. by switching on I.F.F. - by fixing the Very-light colours of the day - etc.).

MEANS OF RECOGNITION

23.5. The R.R.O. determines the identity of reported tracks after considering the evidence provided by:-

(a) Fore-knowledge of movements of friendly aircraft made available by:-

(i) The Raid Recognition Section (paras. 6, 7, 8, 9).

(ii) The Sector Fighter Identification Teller (para. 10).

(b) By track behaviour (para. 11).

(c) By I.F.F. reports from R.R.Us.

(d) From R.O.C. reports.

(e) By radio fixes on friendly aircraft.

(f) By D.R.W. reports concerning enemy air activity.

(g) From sighting reports from friendly aircraft.

(h) From reports of hostile acts.

Raid Recognition Section

23.6. Function. A Raid Recognition Section is enabled in each C.C.F.P. to assist the R.R.O. by receiving information from Movements Liaison Section at the A.T.C.C. concerning movements of friendly aircraft affecting the Sector and to prepare movement sheets (para. 8(b)) for use by the R.R.O.

23.7. Communications. Movements are received from Air Traffic Control Centres (A.T.C.Cs.) (Precis No. 24) by either:-

(a) Teleprinter which is normally used to receive pre-flight information, or

(b) Direct telephone, which is used when last minute changes to flight plans are made, when routes are changed or diversions become necessary.

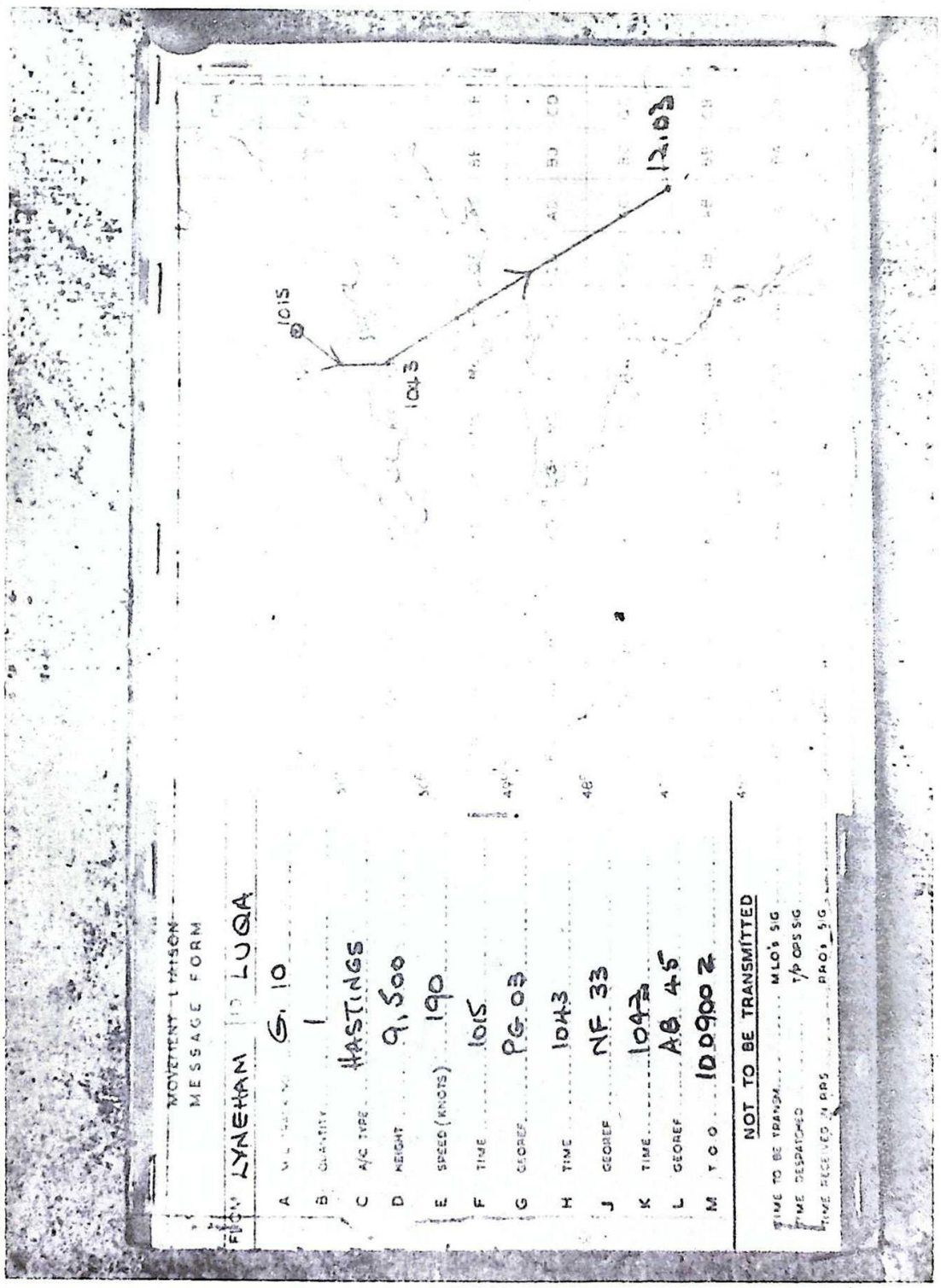
23.8. Movement Forms. The forms used by the raid recognition section are:-

(a) Movement Liaison Message Form. Movements received from A.T.C.Cs. are entered in the log book and copied onto M.L. message forms. Each message form may be used for "Incoming", "Outgoing" or "Internal" movements. Thus a completed M.L. message form would show the following:-

FROM: Point of departure TO: Destination

A.	M.L. Track No.	A.T.C.C. reference number
B.	Quantity	Number of aircraft involved
C.	A/C type	e.g. Hastings, Lincolns etc.,
D.	Height	The height of which certain places (e.g. the coastline) are expected to be crossed.
E.	Speed (Knots)	Self explanatory
F. G.	Time / Georef	Time and position either:- (i) Incoming: when crossing an arbitrary line, related to the limits of reporting cover, or (ii) Outgoing: when crossing out over U.K. coast.
H. J.	Time / Georef	Time and position when half way between the arbitrary line referred to in para. 8(i) and the coast.
K. L.		Time and position either:- (i) Incoming: when crossing U.K. coast, or (ii) Outgoing: when crossing the arbitrary line referred to para. 8(i) above.
M.	T.O.	Time of origin of message at A.T.C.C.

Fig. 1 : Movement Sheet



Precis No. 23, Para. 8(b)

(b) Movement Sheet (Fig. 1). This is a perspex covered chart upon which are entered the details from the message form. The sheet shows:-

(i) A map of the U.K. and approaches.

(ii) Georef graticules - lettering around the edge of the chart.

(iii) Degrees of longitude and latitude.

(iv) The arbitrary line related to the limits of reporting cover referred to in para. 8(i) above.

(v) Main airfields marked in letter code (each R.R. section holds a coded list of airfields).

(c) Naval Weekly Practice Sheet. The R.R.O. is provided with a weekly programme of projected flying to be carried out by Naval aircraft stationed within the Sector area. This sheet shows:-

(i) Naval bases and seaward approaches.

(ii) Lettered zones (not georef).

(iii) Naval flying practices scheduled for each day (e.g. torpedo attacks, air to air firing, target towing for naval A.A. practices etc.).

23.9. Procedure

(a) Movements received from the A.T.C.C.:-

(i) By teleprinter are frequently copies directly onto a movement sheet and entered in the log.

(ii) By telephone are taken down on a M.L. message form, copied onto a movement sheet and entered in the log.

(b) The movement sheet compiled and placed (in chronological order with other sheets) in front of the R.R.Os.

(c) The R.R.O. checks the movements and is able to recognize tracks as they appear on the C.C.F.P. tables from the details in the M.L. sheets. The majority of R.R.Os. decisions result, directly or indirectly from movement sheet information.

23.10. Sector Fighter Identification Teller. This teller acts as the link between the Sector operation room fighter displays and the R.R.O.

(a) The teller is positioned overlooking the sector fighter table and fighter mission tote. He is provided with a two way telephone circuit to the R.R.O. and wears a head and breast set at all times.

(b) He passes to the R.R.O. details of fighter mission as they appear on the tote together with any information requested by the R.R.O. on the whereabouts of any specific fighters as plotted on the fighter table.

23.11. Track Behaviour. Two examples of the recognition of a hostile raid by this method should suffice as explanation:-

(a) In wartime, friendly aircraft are ordered to cross the U.K. coast at prescribed heights within restricted "corridors". Any track which contravenes these regulations might from its behaviour alone, be deemed hostile.

(b) If Radar stations reported raids orbiting over enemy territory and increasing strength and height, such tracks would be recognized as hostile by their behaviour.

23.12. I.F.F. Reports

(a) R.R.Us. report tracks showing I.F.F.

(b) The C.C.F.P. plotter displays the information by means of I.F.F. counters.

(c) The R.R.O. notes the counters and identifies the tracks accordingly.

23.13. R.O.C. Reports. The R.O.C. endeavours within the limits of visibility, to recognize all tracks passed to C.C.F.Ps. thus confirming the identity of overland tracks. The R.R.O. liaises closely with the R.O.C.L.O. (generally adjacent to him on the C.C.F.P. balcony) on matters affecting overland raid recognition.

23.14. Radio Fixes. V.H.F. fixes on a fighter obtained by the Sector fixer service are passed to and displayed on the Sector fighter table. This information is passed to the R.R.O. by the Sector fighter identification teller (see para. 10).

RAID RECOGNITION PROCEDURES

23.15. Recognition Categories. Raid recognition is determined in one of five categories:-

(a) H = HOSTILE

(b) X = UNIDENTIFIED

(c) F = FRIENDLY FIGHTER

(d) M = MIX-UP. This label is used when hostile or unidentified tracks merge with and cannot be distinguished from fighter tracks.

(e) A = ALLIED. This identity is used for all tracks of friendly aircraft (other than fighters).

NOTE 1: When fighter and allied tracks merge and cannot be separately distinguished, the letter "F" or "A" is allotted, according to which type is in the majority.

NOTE 2: When unidentified tracks merge with friendly aircraft the letter "X" is allotted.

SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 24 : AIR TRAFFIC CONTROL

INTRODUCTION

24.1. The primary purpose of air traffic control (A.T.C.) is to promote the safe and speedy movement of aircraft before taking off; while taking off flying and landing; and after landing. This is achieved by many varied activities, which may be grouped thus:-

(a) Regulating and directing flight so as to prevent collisions and accidents and minimize delay.

(b) Guiding pilots in flight towards their destination.

(c) Regulating the movement of aircraft on the ground within the flight areas of airfields.

(d) Issuing navigational and meteorological information to pilots, both before and during flight.

(e) Arranging diversions to other airfields, when the airfields to which pilots are flying become unusable because of bad weather, physical damage or failure of equipment.

(f) Providing distress aids and alerting the search and rescue organization when necessary.

24.2. The air traffic control organization carries out the additional task, important in peacetime and vital in wartime, of supplying to C. & R. systems the information of aircraft movements used to assist in identifying tracks.

24.3. The Air Ministry has agreed that the R.A.F. shall conform to international standards, regulations and procedures for the control and operation of aircraft, as defined by the International Civil Aviation Organization (I.C.A.O.) "so long as they do not conflict with military requirements".

Areas of Control

24.4. The territories and surrounding area of all member-nations of I.C.A.O. are divided into a number of regions, known as flight information regions (F.I.Rs.) within each of which all air traffic control activities are directed from an air traffic control centre (A.T.C.C.). A F.I.R. may include a control area or one or more control zones, and airways may be established passing through one or more F.I.Rs. These terms will be explained later.

24.5. In addition, each airfield exercises local control over all aircraft within its immediate vicinity.

Flight Conditions

24.6. Many of the regulations governing air traffic vary according as a pilot can fly by visual contact with his surroundings or only by reference to his fighter instruments. The two conditions are known respectively as:-

(a) Visual flight rules (V.F.R.)

(b) Instrument flight rules (I.F.R.).

24.7. There are several circumstances under which I.F.R. are enforced, although the weather satisfies V.F.R. conditions.

AIR TRAFFIC CONTROL CENTRES

24.8. There are at present in the United Kingdom four F.I.Rs. - Scottish, Northern, South-Western and South-Eastern. The A.T.C.Cs. are situated at:-

Prestwick	Scottish F.I.R.
Preston	Northern F.I.R.
Gloucester	South-Western F.I.R.
Uxbridge	South-Eastern F.I.R.

In addition a sub-centre to Preston has been established at Watnall solely for R.A.F. traffic.

24.9. An A.T.C.C. is responsible in its F.I.R. for:-

(a) Controlling aircraft flying in control areas and airways under I.F.R.

(b) Supervising the control (exercised by local approach controls) of aircraft entering, leaving or flying within control zones under I.F.R.

(c) Co-ordinating diversion, overdue and emergency actions.

(d) Alerting search and rescue action.

(e) Maintaining up-to-date information concerning airfields, navigational warnings and navigational landing and distress aids.

(f) Providing navigational and meteorological information to pilots.

(g) Maintaining a movement liaison section (M.L.S.) to provide information to C.C.F.Ps. concerning movement of friendly aircraft.

CONTROL ZONES, CONTROL AREAS AND AIRWAYS

24.10. Control zones, control areas and airways are air spaces within which all flying is subject to rules additional to those governing normal flight.

24.11. Control Zones. Control zones, of which a number now exist in the British Isles, are established to protect aircraft entering or leaving busy airfields.

24.12. Control Areas. Control areas, of which that surrounding the London Control Zone is the only one in the British Isles at present, are established where the amount of "en route" traffic demands an added degree of control over all flying.

24.13. Airways. A network of airways, designed to protect commercial aircraft moving along busy air routes between main airports has been established over the United Kingdom.

Flying by Fighter Aircraft in the Controlled Airspaces

24.14. Special regulations govern the movement of military aircraft using R.A.F. airfields located within control zones and control areas.

24.15. V.F.R. Conditions. Military aircraft flying through control zones, control areas or airways under V.H.F., are not subject to many rules particular to those controlled airspaces.

24.16. I.F.R. Conditions. Fighter aircraft flying through control zones, control areas and airways under I.F.R. must satisfy one of the following conditions:-

(a) Full compliance with the regulations governing the movement of all classes of aircraft flying in the airspace.

(b) Flight under approved radar control.

AIRFIELDS

Runways

24.17. Permanent airfields used for fighter operations usually have three concrete runways. There is some variation in the size of these but the standard width of runways is 50 yds. and standard lengths are 2,000 yards for the main runway, and 1,600 and 1,400 yards for the two subsidiary runways. Runways are numbered in accordance with the magnetic heading of the approach; a two figure number representing the heading to the nearest 10^{0}, is used.

Master Airfields

24.18. Master airfields are those which, in addition to their normal service function, act as diversion airfields and essential links in the emergency organization. Distributed throughout the United Kingdom, they are open 24 hours a day.

AIDS TO APPROACH AND LANDING IN POOR VISIBILITY

24.19. A major problem in fighter operations is that of landing a large number of aircraft rapidly in bad weather. Fighter Command has experimented with many approach - control systems but has yet to find one which meets all its requirements.

24.20. The following methods of making bad weather approaches to airfields are used by fighters:-

(a) Q.G.H. This is a method whereby a pilot is guided from the ground by V.H.F. R/T so as to descend safely through cloud and into the close proximity of the airfield. Bearings taken by a V.H.F. D/F station (Homer) are employed.

(b) Gee Let Down. Night and all-weather fighters in the R.A.F. are fitted with the Gee navigational aid. This can be used by the aircraft crew as a means of conducting their own approach to an airfield with a fair degree of precision.

(c) Ground Controlled Approach (G.C.A.). This is a high-precision radar approach aid. A G.C.A. unit is equipped with two radars, a search system and a precision system. Aircraft are suitably positioned, by means of the search system, downwind of the runway in use. They are then passed to the talkdown controller, who is using the precision system guides them in the final approach.

SECTION VI : TECHNIQUES AND PROCEDURES

PRECIS 25 : LINE COMMUNICATIONS

INTRODUCTION

25.1. The majority of ground communications within the C. & R. system in the United Kingdom are conducted over a netwoek of landlines maintained by the G.P.O. These lines are known as:-

(a) P.W. (private wires). These are direct lines rented from the G.P.O. on a permanent basis, between one operations point and another (e.g. Control Executive and Chief Controller at a G.C.I. station).

(b) E.C. (emergency circuit). These lines are available for use by the general public except when required for service use, they can be made available at short notice.

(c) P.U.T. call (prolonged uninterrupted trunk call). These calls are made on ordinary public lines but are free from interruption. They are used to meet abnormal needs of a few hours duration.

(d) Internal Extensions. These are the lines over which internal communications within operations buildings are carried out (e.g. keyboard to keyboard, switchboard (P.B.X.) to places of duty of lay personnel etc.).

25.2. The following paragraphs describe the telephone equipment used by the fighter plotter in the course of his duties, and the techniques adopted for their use.

TELEPHONIC EQUIPMENTS

25.3. The telephonic equipment currently used and operated by the fighter plotter comprises:-

(a) Microphone-Telephones. Handsets and "head and breast" sets are used, the latter is used wherever it is important to free the hand for manipulative tasks.

(b) Multi-line keyboards. These are 10 - 20 - 30 or 40-line keyboards; all are operated in the same way.

(c) Change-over Panels (C.O.P.). These panels are installed in many operations rooms.

Description of Telephonic Equipment

25.4. Telephones

(a) Handset. This instrument rests in a "cradle" which embodies a cut-off switch, contact being made with caller or switchboard, when telephone is lifted.

(b) Head and Breast Set. This instrument comprises:-

(i) A single earphone on headband (NOTE)

(ii) A switchable microphone attached to the mouthpiece (i.e. the microphone is switched off when the mouthpiece is moved away from the mouth).

(iii) A lead and plug which when coupled to a terminating jack, allows freedom of movements to the wearer.

NOTE: G.S.M. plotters receive information over uni-directional (one-way) lines and it is not necessary for them to have the mouthpiece.

25.5. Multiline Keyboard. Key personnel within the C. & R. system are provided with multiline keyboards which enable them to contact those personnel with whom rapid and direct communication is essential. Fighter plotters are generally called upon to assist key personnel by operating those keyboards. The 20 line keyboard comprises:-

(a) Two telephones - left and right hand sides of the keyboard.

(b) 20 "two-way" keys - each of which can switch a circuit to either of the two telephones:-

(i) Key forward - use left hand phone.

(ii) Key backward - use right hand phone.

Keys are maintained in the upright position when not in use.

(c) Indicator lights - two to each circuit.

(i) White showing - indicates a call;

(ii) Red showing - indicates "line engaged".

(d) Ringing keys - for left and right hand phones.

(e) Buzzer out-off key. The purpose of the buzzer is to attract the attention when an incoming call is received. The buzzer can be cut off whilst operator is answering a call, or is present at the keyboard.

(f) 20 "line-connecting" jacks, one to each circuit. By means of connecting cords (short lines with a plug at each end) any two circuits on the keyboard can be connected.

25.6. Changeover Panel (C.O.P.). The purpose of the changeover is to have one control point at which all lines terminate and whence they can be routed as desired. For example the C.C.F.P. C.O.P. comprises:-

(a) Terminating jacks for lines connecting plotters and tellers to:-

(i) Radar stations.

(ii) R.O.C. centres.

(iii) A.A.O.Rs. (the army have their own system for telling to G.S.Ms. at A.A.O.Rs. and employ army personnel on telling duties).

(b) Linking lines to specified keys on keyboards within the operations building (e.g. floor supervisor, filter officer etc.).

(c) Common "linking-jacks" by means of which any circuit may be connected to a number of positions within the operations room. During periods of intense air activity a busy line can be routed to say two positions on the table and the work can be shared by two plotters.

(d) Monitoring positions. Use of these jacks enables the supervisor to monitor any line routed through the G.O.P. without interrupting the flow of information.

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